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The Ziptrack Integrator

Ernest N. Prabhakar

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ERNEST N. PRABHAKAR, 7279

Summer Student in the
Research Division/Research Facilities Department
from the Massachusetts Institute of Technology

August 15, 1986

Abstract

This Technical Memo is a brief 'Owners Manual' describing the operation and design of THE ZIPTRACK INTEGRATOR.

Acknowledgements

The ZIPTRACK INTEGRATOR was developed by Ed Schmidt of the Magnetic Measurement Group. The four integrators portrayed herein were built by Chuck Mangene of the Research Facilities Department. They are in no way responsible for either the tone or the contents of this manuscript.

The author is deeply indebted to Wilcox Yang of the Research Facilities Department, who not only hired me and assigned me to this project, but was always willing to give me extra time to work on it. Chuck Mangene deserves special commendation for putting up with my constant and often inane questions. Finally, many thanks are due to Stephen Pordes of the Research Division for his constant encouragement and suggestions for improvement. If any errors remain, they are the sole responsibility of the author.

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1 Introduction

Congratulations! You are now the proud owner of the Original, Authentic, Internationally Famous, Critically Acclaimed, All New and Improved ZIPTRACK INTEGRATOR MANUAL. The INTEGRATOR was originally developed for use with that nationally renowned Magnetic Measurement Device, *The Ziptrack*. Its accuracy and reliability, however, make it the right choice for any need, as well as the perfect gift.

2 Operation

Although a sophisticated piece of equipment, the ZIPTRACK INTEGRATOR is designed to be easy to use. It's so advanced, it's simple! This section covers everything you will ever want to know about using the INTEGRATOR, provided you don't want to know too much. Information covering the internals of the INTEGRATOR is found in Section 3 on page 5.

2.1 Input/Output

The front and back of the INTEGRATORS are covered with sockets, dials, and LEDs to tell you what is going on, as well as let you do something about it. For your convenience, Figure 1 on page 2 is a schematic representation of the cable connections on the back of the INTEGRATOR. Here, for the first time, is a complete listing of what they are and what they do:

Power Supply As any Electrical Engineer will tell you, "It don't work if it ain't plugged in!" At least, he might if he studied English at M.I.T. To help avoid this difficulty, there are two different ways to plug in the INTEGRATOR. Either $115VAC$ on A-B of a three pin Burndy connection, or else the standard NIM crate connector with $\pm 24VDC$ and $115VAC$. These are both located on the rear of the module. For added ease, a double-throw selector is located on the front, with LEDs to identify where the power is coming from.

Operating Voltages The Input Signal and Output Voltage are connected using sockets in the back. They are both standard, four-pin Burndys of which only three pins are used. A is Signal, B is Ground, and C is Shielding. B and C can be tied together for use with a coaxial cable. The male socket is Input, and the female is Output.

Time Constant The Input Signal and Output Voltage are related by the reciprocal of the Time Constant. This value can be adjusted by the multi-position switch on the front. The Time Constant can take on any of eight values spanning three and a half decades. See Section 2.3 for more details and the exact values.

Drift Zero The ZIPTRACK INTEGRATOR is replete with features to deal with Drift. There are two potentiometers, one for dealing with the Input Offset Current, and the other for dealing with the Input Offset Voltage. To trim the Current, first set the Time Constant selector to *Current Trim*. This open circuits V_{in} . Next, insert a small screwdriver into the adjacent hole where the potentiometer control is located. Turn the screwdriver in either direction until the drift is reduced to a minimum.

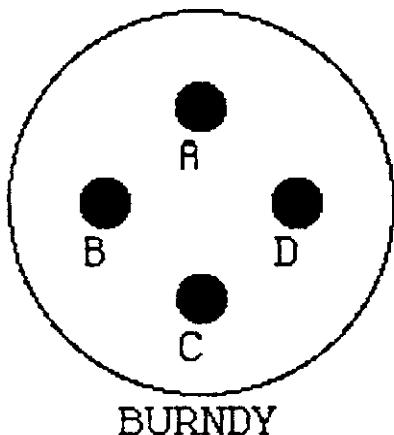
Voltage Trim is even easier. The Time Constant should be set to whatever it will be at during actual use, and the Input Signal should be zero. With the Local/Remote switch at *Local*, turn the Drift Zero knob until the drift is minimized. Turn the knob clockwise to compensate for positive drift, and *vice versa* for negative drift. With proper use, the drift can be reduced to under 5 mV/minute.

With the Local/Remote switch in the *Remote* position, the voltage at the D/A Input is added to the offset voltage, allowing both manual and electronic control over drift. The Status lemo connector is open circuited for *Local* mode and grounded when in *Remote* mode. Other models sometimes carry additional information at the Status connector.

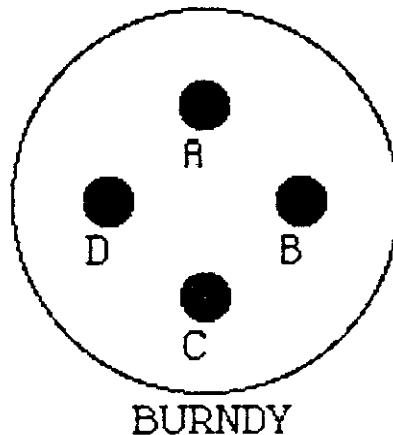
Overload Skipping back up to the top of the module, we find the Overload readouts. These include a LED for human reading and a lemo connector which gives a logical true. The signal is latched, so that it will remain high until Reset is pushed, even if the INTEGRATOR is not still saturated. When the INTEGRATOR becomes Overloaded, it usually means that the gain has to be reduced. (*i.e.*, the Time Constant must be increased).

Figure 1: Schematic Representation of Rear Cable Connections

OUTPUT

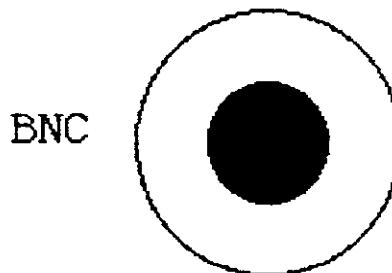


INPUT

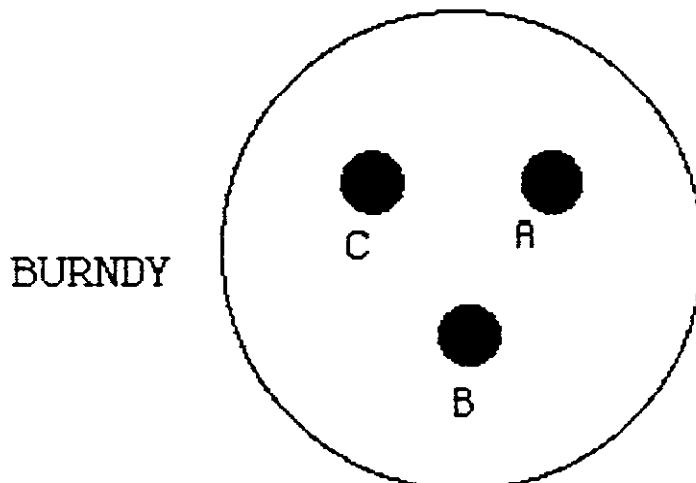


**A=SIGNAL
B=GROUNd
C=SHIELD**

RESET



POWER



**A=115V AC
B=NEUTRAL
C=GROUNd**

Reset This is a pushbutton located directly below the Overload signals. This sets the INTEGRATOR to zero, and produces a one second signal. This signal lights the accompanying LED and sends a down transition through the BNC connector in back. This rear connector works both ways, in that a logic low coming in will also Reset. A bank of INTEGRATORS can be hooked together, as well as to a controller, allowing simultaneous Reset.

2.2 Operating Conditions

Although sturdily built, the ZIPTRACK INTEGRATOR is *not* a piece of Samsonite Luggage. It will work in just about any environment with as much efficiency as a human being would in that environment. One major consideration is ensuring that it has reached thermal equilibrium before readings are taken, as the resistances are somewhat temperature dependant. A twenty minute warm-up period is suitable.

The INTEGRATOR needs a stable power supply to produce a stable output. In practice, the Ziptrack powers them through a 115VAC line conditioner. There is no real limit on input voltages, though anything over 200mV will cause near-instant saturation. Output voltage saturation occurs at $|V_{out}| > 10V$.

2.3 Operational Characteristics

The main feature of any integrator is the Time Constant. On the ZIPTRACK INTEGRATOR the Time Constants are within 1% of the nominal values. The values are tabulated in Table 1 on page 4. Detailed information can be found in Appendix B on page B.1. The INTEGRATOR has a fixed capacitance of 1 μF . Thus, the input resistance is simply the Time Constant times 10^6 .

Table 1: Nominal vs. Actual Time Constant

Nominal [msec]	Fitted to Data		
	$V_{in} < 0$	$V_{in} > 0$	$V_{in} \neq 0$
— Integrator Number 1 —			
0.10	0.10128	0.10110	0.10127
0.30	0.30246	0.30264	0.30282
1.00	1.00849	1.00866	1.00868
3.00	3.03114	3.03125	3.03101
10.00	10.08302	10.08283	10.08272
30.00	30.24905	30.25040	30.24941
100.00	100.01691	100.01614	100.01709
300.00	300.30704	300.28298	300.30134
— Integrator Number 2 —			
0.10	0.10110	0.10096	0.10105
0.30	0.30205	0.30205	0.30216
1.00	1.00610	1.00611	1.00619
3.00	3.02519	3.02534	3.02530
10.00	10.06160	10.06177	10.06166
30.00	30.18876	30.18787	30.18863
100.00	99.93402	99.93471	99.93434
300.00	300.12434	300.13753	300.15500
— Integrator Number 3 —			
0.10	0.10121	0.10115	0.10095
0.30	0.30221	0.30124	0.30232
1.00	1.00728	1.00734	1.00732
3.00	3.02464	3.02470	3.02470
10.00	10.06761	10.06777	10.06766
30.00	30.19350	30.19316	30.19374
100.00	99.82003	99.81884	99.81861
300.00	300.07418	300.06205	300.07006
— Integrator Number 4 —			
0.10	0.10068	0.10073	0.10080
0.30	0.30160	0.30157	0.30157
1.00	1.00449	1.00447	1.00446
3.00	3.02023	3.02018	3.02022
10.00	10.04265	10.04260	10.04250
30.00	30.12842	30.13008	30.12880
100.00	99.58312	99.58325	99.58334
300.00	299.10117	299.06792	299.08931

3 Design

The ZIPTRACK INTEGRATOR has undergone many stages of evolution leading up to the present wonder of engineering. Hard as it may be to believe, improvements are continually being made. The present model is a balance between economy, reliability, and aesthetics. It was designed with hard work in mind. Chuck Mangene¹ described it as a 'marvel of redundancy'.

3.1 The Circuit

All integrators have an Op Amp, a capacitor, and a resistor or two. What makes this INTEGRATOR unique is the control circuitry. The design is very modular, as shown in the schematic in Figure 2. This makes it easy to specialize or upgrade the integrator. Many parts were upgraded to the state-of-the-art just for this shipment.

Integrator The integrator is an Analog Devices 234L chopper-stabilized Op Amp with $1 \mu\text{F}$ of capacitance and variable resistance. A capacitor array isolates the Op Amp from $\pm V_{cc}$. Trim is connected to the *Drift Control* circuit.

Drift Control A $50K\Omega$ potentiometer and two AD517K Op Amps are the heart of the *Drift Control* circuitry. The potentiometer functions as a voltage divider, and uses the first Op Amp as a buffer. The second Op Amp is used to add in the D/A Input when the Local/Remote switch is in the *Remote* position. This voltage is used as the *Trim* input on the *Integrator*.

Overload Alas, even this technological wonder can sometimes be overworked. Comparators check for $|V_{out}| > 10$. When this happens, digital logic sets the *Overload Latch*. This turns on the red LED and gives a logic low to the *Overload* lemo connector. This stays set until reset by *Reset*.

Reset The function of this signal is to reset the integrator to ground state. It can be initiated by pushing a switch or by giving a down transition to the BNC connection in the back. It is gated to have a pulse width $T \approx 1$ second. The integrator capacitor is shorted out by a small resistor for this amount of time. In addition, a red LED is turned on to show that the resetting process is going on, and the connector in the back is sent a logic low. As mentioned earlier, this also resets the *Overload Latch*.

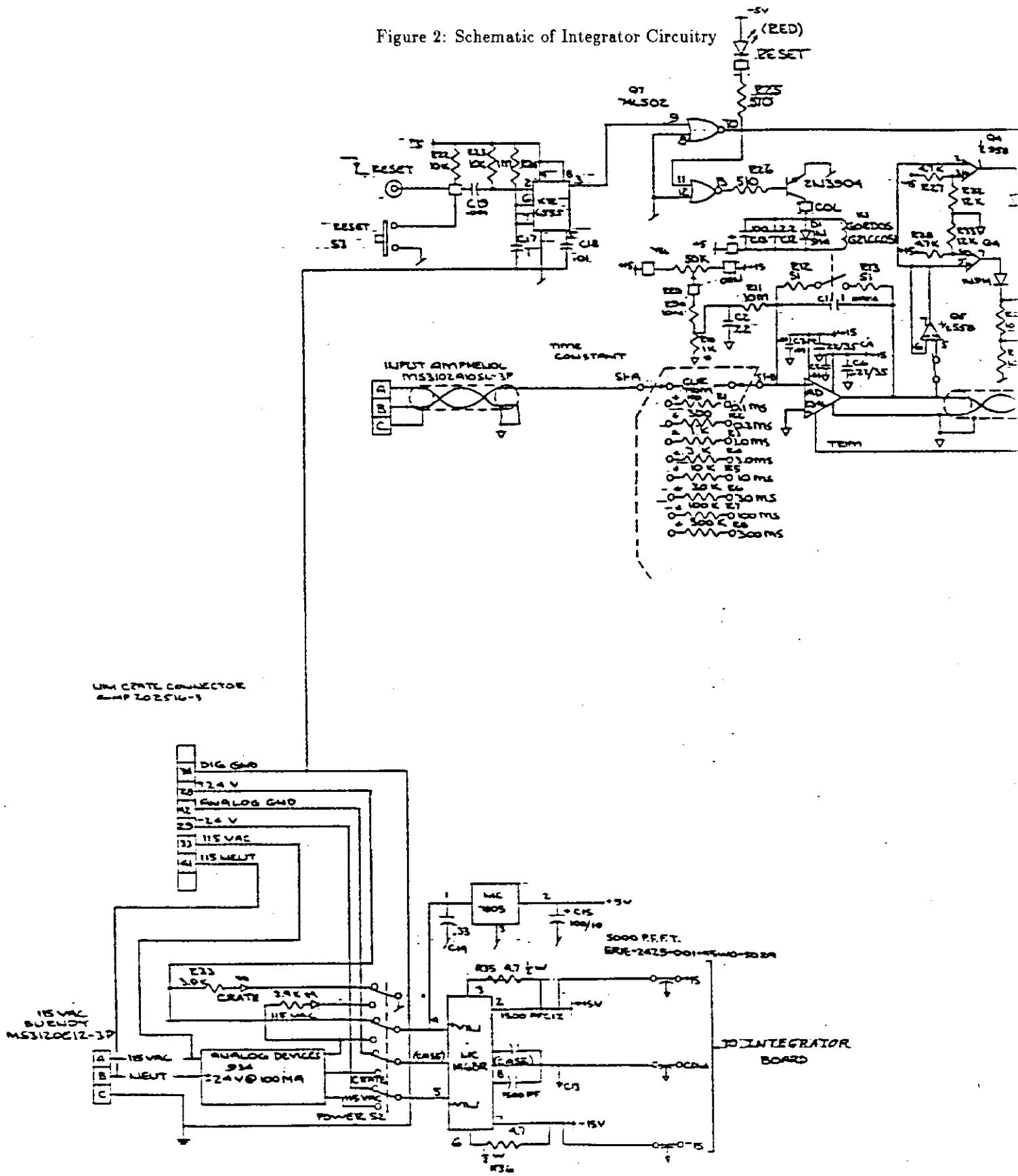
Power Supply The power is fully switchable between an External $115V AC$ and the Internal NIM crate supply. An AD 934 turns the $115V AC$ into $24V DC$. From there, an MC 1468R is used to give the $\pm 15V$ needed for Op Amps. A MC 7805 provides the $+5V$ needed for the digital logic.

3.2 Spare Parts

While sturdy, the ZIPTRACK INTEGRATOR is by no means indestructible. This being the case, here is a list of spare parts which might be of use to you. Table 2 on page 8 is a complete list of all parts used in manufacturing the integrator.

¹Research Division/Research Facilities Department

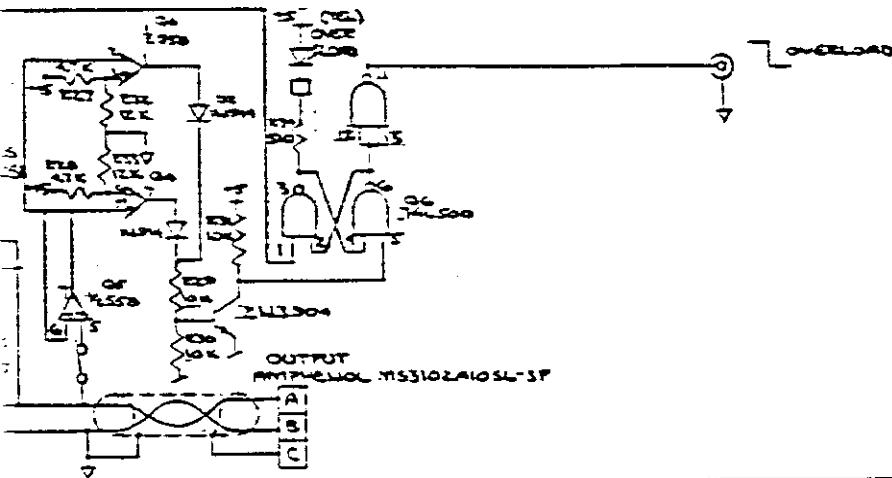
Figure 2: Schematic of Integrator Circuitry



3.2 Spare Parts

7

NR.	DESCRIPTION	DRAWN BY	DATE
A	REVISED & REDRAWN	WILLARD	5-30-63
B	ADDED DA-155	RCB	10-1-63
C	CHANGED WIRE NO'S	RCB	10-30-63
D	GEN. REV		
E	DELETED DA-155 MADE FROM ED-144185	PMT	10-1-63

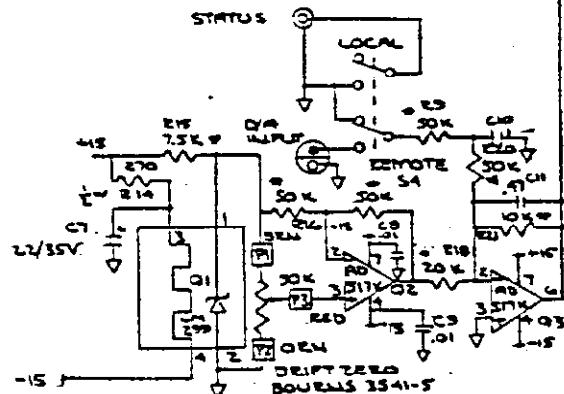


ALL CAPACITORS IN MF UNLESS NOTED.

RESISTORS LISTED WITH #
ARE VISHAY TYPE SURFACE
CRODICK TYPE TX133

POWER GROUND = CONNECTED
TOGETHER AT
DIGITAL GND AND ANALOG GND
IN CASE

INTEGRATING CAPACITOR C1 IS
A COMPONENT RESEARCH CA 24C
TYPE J11C105RA



UNLESS OTHERWISE SPECIFIED	DRAWN BY	R. SCHMIDT
FRACTIONS DECIMALS AND/OR	WILLARD	5-30-63
1. DRAW ALL VISIBLE EDGES LINES. 2. DO NOT SCALE STYL.	APPROVED	
3. DIMENSIONS IN ACCORD WITH THIS TITLE SHEET. 4. DRAW ALL PARALLEL SURFACES	USED ON	
MATERIAL:		
FERMI NATIONAL ACCELERATOR LABORATORY U.S. DEPARTMENT OF ENERGY		
TEVATRON I MAGNET MEASUREMENTS INTEGRATOR		
SCALE	PLATED	DRAWING NUMBER 1670-ED-213330

Table 2: ZIP TRAK INTEGRATOR Spare Parts List

Part	Type	Part	Type
†R1 ¹	100Ω	Q1	LM299
†R2	300Ω	Q2,Q3	AD517K
†R3	1KΩ	Q4	1450
†R4	3KΩ	Q5	7L0C
†R5	10KΩ	Q6	74LS00
†R6	30KΩ	Q7	74LS02
†R7	100KΩ	Q8	VE555
†R8	300KΩ	Q9	74LS147
†R9	50KΩ	Q0	Analog Devices 234L
†R10	1KΩ	D1	IN914
R11	10MΩ	T1,T2	2N3904
R12,R13	51Ω	U1	MC1468R
R14	270Ω - 1/2W	U2	MC7805
†R15	7.5KΩ	K1	SIGMA #196 RETC 3K-5G
†R16,†R17	50KΩ	DPDT	Local/Remote
†R18	20KΩ	S1	Dip Switch (8)
*R19,†R20	50KΩ	S2	Power: CRATE/115VAC
R21	10KΩ	—	ALCO MTA-406N, 4PDT
R22-R30	1KΩ	S3	Reset Switch
R22,R23	10KΩ	S4	Centralab Ceramic
R24	1MΩ	S4(2)	Switch Index PS-21
R25,R26	510Ω	S4(1)	Switch Index P-510
R27,R28	4.7KΩ	ALCO Knobs(2)	PKGP-90B-1/4
R29-R31	10KΩ	Output Conn.	Burndy GOB 10 4SNE
R32,R33	12KΩ	Input Conn.	Burndy GOB 10 4PNE
R34	510Ω	Reset Conn.	BNC
R35,R36	4.7KΩ - 1/2W	Power Conn.	Burndy MS3120 E12 3P and Mate MS
POT1	10T, 50KΩ	Power Supply	AD394 ±24V@100mA
POT2	10T, 50KΩ, Trim	Bud Convera-Box	Type C4-482, 2" x8" x4"
C1 ²	1μF	16 Ribbon Cable	Dip interconnect
C2	22μF	—	5000P.F. F.T. ERIE
C3	0.01μF	—	2425-001-X5WO-502A
C4	22/35 μF	HEATSINK1	Thermalloy Type 6032B
C5	0.01μF	HEATSINK2	Thermalloy Type 61.66C
C6,C7	22/35 μF	Lemos (3)	
C8,C9	0.01μF	LEDs (4)	
C10	1μF	Shaft Couplers(2)	
C11	0.47μF	Module	2 width NIM module
C12,C13	1500pF	Module Conn	
C14	0.33μF	P.C. Boards(2)	
C15	100/10 μF		
C17	1.00μF		
C18	0.01μF		
C19	0.33μF		

Revised: Spring, 1986

¹ Resistors with † are vishay Type S102C or caddock Type TK113. (1% Tol., 10ppm/°C)² C1 is a component of Research Co., Inc., Type J121C105FXA.

4 Calibration

The calibration was performed at the Magnet Testing Facility (MTF). Data was taken over the course of a week on all four integrators. These measurements are shown on page A.1 in Appendix A. They were entered into the computer using the **20/20** spreadsheet program.

From this data, the Time Constants were calculated. The results of these calculations are shown in Appendix B on page B.1. As you saw in Table 1 on page 4, the Time Constants differed from their nominal value by less than 1%.

The linearity of these values is shown to be better than one part per thousand. Appendix C on page C.1 lists the difference between $Y_{predicted}$ and $Y_{measured}$ for each point. Appendix D on page D.1 is a graphical view of that same data.

4.1 Precision Pulse Generator (PPG)

The Precision Pulse Generator **PPG**, shown in Figure 3, is at the heart of the calibration process. It is supposed to take a given input voltage and produce a pulse of that amplitude. The pulse is at least consistent, if not exactly equal to its nominal value. The voltage, however, is not very well behaved. Here is a quick rundown of the design:

Voltages This part of the circuit actually carries the signal voltages to be passed on to the integrator. For this reason, its power and signals are totally isolated from the rest of the circuit. The only connections are the optical isolator and the mercury relay.

The optical isolator runs a power FET which switches between V_{in} and GND. From there, Op Amps transmit the voltage to the mercury relay, which opens and closes the path to $V_{monitor}$. A $15K\Omega$ to 150Ω bridge between $V_{monitor}$ and ground gives a 1:100 voltage divider for V_{out} . Of course, smaller RC values in the integrator tend to create larger voltage division.

Pulse Duration Pulse production can be initiated by either the debounced switch or the lemo connector. They clear the flip-flops which control the switching. The LS73 is wired as a D flip-flop, and controls the mercury relay as well as the Pulse LED. The LS78 is wired as a dual latch, and it controls the Pulse lemo connector and the optical isolator.

When the relay is closed and the FET switched to V_{in} , the 4059 is triggered. The 4059 waits the amount of time specified by the thumbwheel switches, then sets the flip-flops. This extinguishes the LEDs, opens the relay, and sets the FET back to ground.

4.2 Sources of Error

The calibration procedure is to input a known voltage for a fixed amount of time and measure the resultant output voltage. The module responsible for gating the input voltage, the **PPG**, seemed linked to most of the calibration errors. These can be broken down into the following categories:

Pulse Width This is actually quite well controlled. Nominal pulse width varied from two to thirty seconds. Actual values were 2.0220 and 30.0225 seconds, with an uncertainty of less than 1 millisecond. In the worst case this gave an error of 1 part per 20,000, which was far less than most other sources.

Input Voltage The DC Voltage standard used as a power source is very accurate. Unfortunately, it had to pass through the **PPG**, which used a voltage divider with much less stability. This divided the input voltage by a factor of 100. The voltage reduction was much greater when working with the smaller time constants and correspondingly lower input resistances.

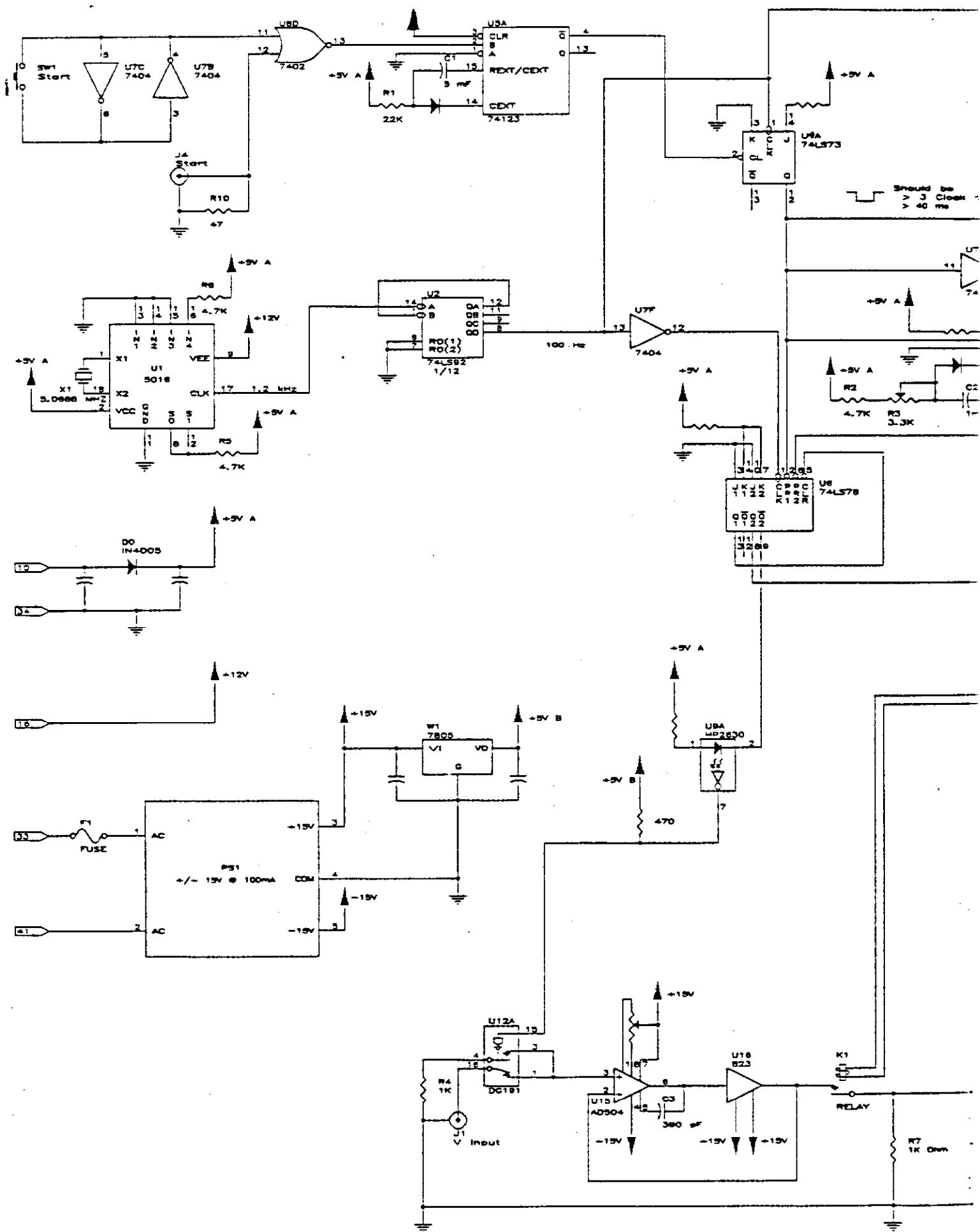
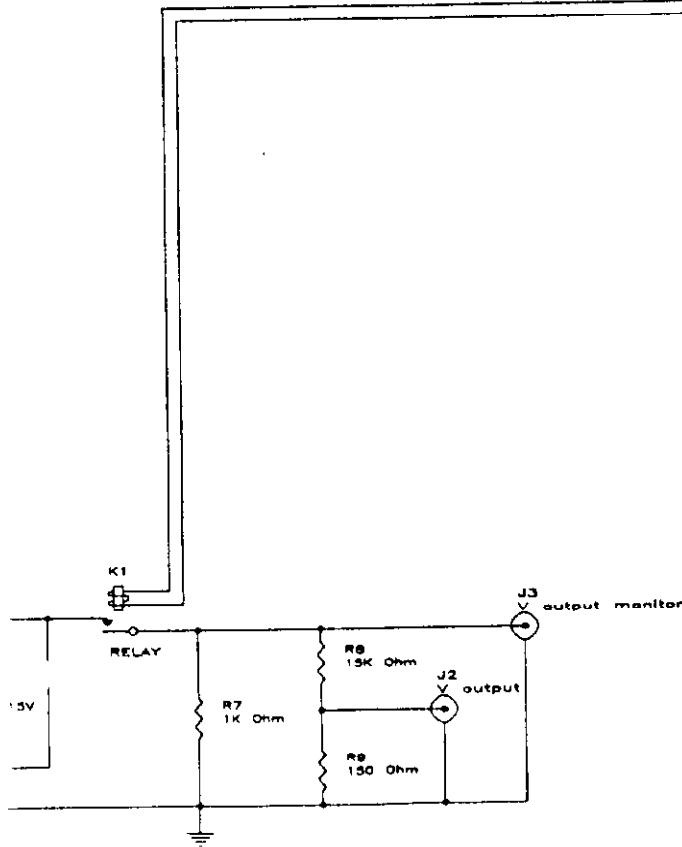
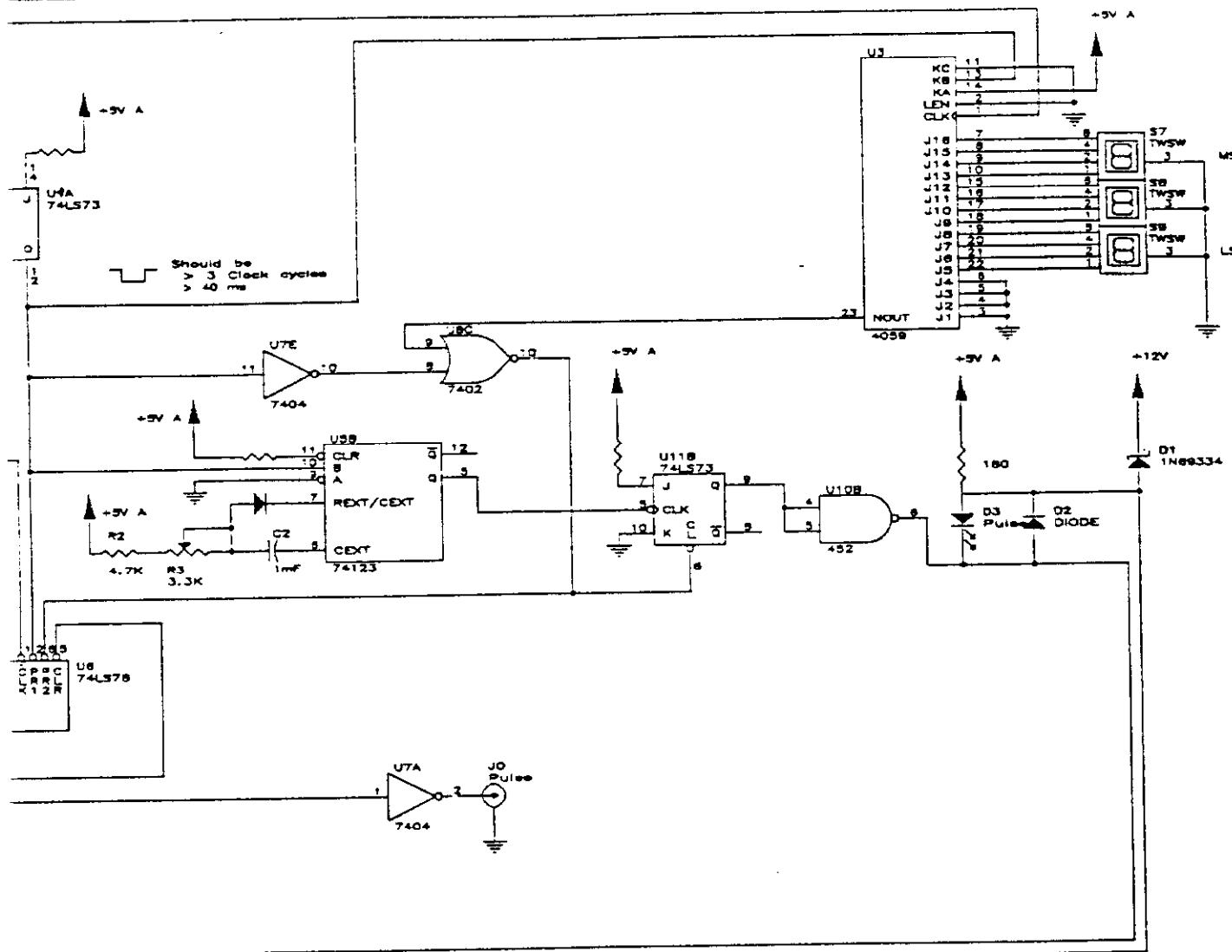


Figure 3: Precision Pulse Generator (PPG)

NOTES:
K1 is a Mercury-wetted Relay Co.



TEST:
Is a Mercury-wetted Relay Contact

Precision Pulse Generator	
Ernest N. Prabhakar 7279	
Research Division / RFD	
Fermi National Accelerator Laboratory	
United States Department of Energy	
Title: Precision Pulse Generator	
Size: C	Document Number: 1
REV: b	

Table 3: Uncertainty in measurement of Output Voltage

Time Constant [msec]	Amplitude of Drift μV	Percentage Error error:output
.1	500	1:10,000
.3	200	1:20,000
1.0	100	1:50,000
3.0	30	1:200,000
10.0	5	1:1,000,000
30.0	4	1:500,000
100.0	2	1:2,000,000
300.0	1	1:5,000,000

There were also variations of the input voltage on the order of a microvolt. The Input DVM, however, took the arithmetic mean of the voltage with a sampling rate of about 3 Hertz. This reduced the uncertainty in the input voltage to about $.1 \mu\text{V}$, or 1 part in a 1000 for low voltages. For larger time constants with longer pulse widths, the error would be an order of magnitude or two smaller. This was the major source of error in most measurements.

Output Voltage There was a certain amount of leakage voltage coming through the INTEGRATOR. This necessitated constant re-zeroing of the drift. Variations in the input current made it impossible to make the drift exactly zero. The best that could be accomplished was to have bound oscillations. The amplitude of these oscillations was roughly proportional to gain. The error and corresponding uncertainty are shown in Table 3.

4.3 Goodness of Fit

The Time Constant was calculated by fitting a line of the form $Y = M * X + B$. The Y value was the output voltage, and X was the input voltage times the pulse width. This means that M was the negative reciprocal of the Time Constant, and B was the Offset Voltage integrated over the pulse width, scaled by M . The fit was produced using the International Mathematical and Scientific Library (IMSL) subroutine RLONE, which produces a least-squares fit.

The fit was made to three different sets of the data. The first set included only those measurements where $V_{in} < 0$, while the second had those for which $V_{in} > 0$. The third was a global fit, and so included all values of $V_{in} \neq 0$.

The agreement of Predicted to Measured was excellent. When plotted simultaneously on a 8.5 x 11 piece of paper, it was impossible to distinguish between the two. For $RC = 0.1$ and 0.3 msec, the point by point error was about 1 part per 1000. For larger time constants, the error was an order of magnitude smaller. See Appendix C on page C.1 for a full tabulation of errors, point by point. Appendix D contains graphs of that same data. The errors from the fits $V_{in} < 0$ and $V_{in} > 0$ are shown under Local, while those for $V_{in} \neq 0$ are found under Global.

A Calibration Measurements

Here is a complete listing of all the data points taken during calibration testing. There are four sets, one for each integrator. First is the nominal RC product in *milliseconds*. Next is the pulse duration *Time in seconds*. The output and nominal input voltages, V_{out} and $V_{nominal}$, are in *volts*, whereas V_{in} is in *millivolts*. The data is divided into two columns, one each for positive and negative input voltages.

Table 4: Integrator No. 1001 Calibration Data

RC	Time	V_{nominal}	$V_{in} < 0$	V_{out}	$V_{in} > 0$	V_{out}
0.10	2.022	0.00	0.00088	0.06118	0.00000	0.00000
	2.022	0.02	0.08104	1.65646	0.07960	1.53180
	2.022	0.04	0.15944	3.25149	0.15910	3.12846
	2.022	0.06	0.24122	4.84755	0.23876	4.72338
	2.022	0.08	0.32092	6.44186	0.31866	6.31740
	2.022	0.10	0.40092	8.03882	0.39844	7.91475
	2.022	0.12	0.47956	9.63280	0.47832	9.50749
0.30	2.022	0.00	0.00290	0.03352	0.00000	0.00000
	2.022	0.03	0.20342	1.36118	0.19574	1.29301
	2.022	0.06	0.40098	2.68763	0.39508	2.61916
	2.022	0.09	0.59968	4.01613	0.59296	3.94585
	2.022	0.12	0.79788	5.34129	0.79204	5.27267
	2.022	0.15	0.99632	6.66891	0.99058	6.60082
	2.022	0.18	1.19552	7.99587	1.18940	7.92772
	2.022	0.21	1.39392	9.32198	1.38732	9.25372
1.00	2.022	0.00	0.00500	0.01370	0.00000	0.00000
	2.022	0.10	0.86692	1.74156	0.85716	1.71467
	2.022	0.20	1.72922	3.46984	1.71970	3.44267
	2.022	0.30	2.59202	5.19781	2.58064	5.17083
	2.022	0.40	3.45360	6.92596	3.44402	6.89932
	2.022	0.50	4.31456	8.65464	4.30506	8.62648
3.00	2.022	0.00	0.00800	0.00479	0.00000	0.00000
	2.022	0.30	2.83562	1.89316	2.82380	1.88332
	2.022	0.60	5.66660	3.78142	5.65494	3.77164
	2.022	0.90	8.49790	5.66969	8.48586	5.65992
	2.022	1.20	11.32788	7.55757	11.31664	7.54789
	2.022	1.50	14.15778	9.44608	14.14632	9.43622
10.00	2.022	0.00	0.00344	0.00155	0.00000	0.00000
	2.022	1.00	9.76122	1.95795	9.74990	1.95490
	2.022	2.00	19.51666	3.91444	19.50540	3.91133
	2.022	3.00	29.27100	5.87087	29.26200	5.86775
	2.022	4.00	39.03040	7.82743	39.01890	7.82432
	2.022	5.00	48.78570	9.78383	48.77290	9.78064
30.00	2.022	0.00	0.00752	0.00054	0.00000	0.00000
	2.022	1.00	9.85744	0.65907	9.84494	0.65799
	2.022	2.00	19.70942	1.31760	19.69940	1.31655
	2.022	3.00	29.55950	1.97615	29.55010	1.97510
	2.022	4.00	39.41400	2.63474	39.40320	2.63369
100.00	20.022	0.00	0.00185	0.00152	0.00000	0.00000
	20.022	0.05	0.49953	0.10047	0.48909	0.09742
	20.022	0.10	0.99496	0.19937	0.98334	0.19640
	20.022	0.15	1.48758	0.29838	1.47775	0.29534
	20.022	0.20	1.98327	0.39734	1.97215	0.39430
	20.022	0.25	2.47748	0.49629	2.46624	0.49327
	20.022	0.30	2.97018	0.59522	2.96055	0.59220
	20.022	0.40	3.96049	0.79313	3.94929	0.79014
	20.022	0.50	4.94914	0.99106	4.93790	0.98801
	20.022	0.60	5.93737	1.18894	5.92663	1.18593
	20.022	0.80	7.91424	1.58475	7.90370	1.58178
	20.022	1.00	9.89172	1.98057	9.88073	1.97757
	20.022	1.50	14.83489	2.97013	14.82403	2.96713
	20.022	2.00	19.77789	3.95968	19.76708	3.95662
	20.022	2.50	24.72100	4.94924	24.71010	4.94625
	20.022	3.00	29.66380	5.93869	29.65290	5.93569
	20.022	3.50	34.60700	6.92825	34.59600	6.92529
	20.022	4.00	39.55060	7.91789	39.53990	7.91492
	20.022	4.50	44.49400	8.90746	44.48300	8.90450
	20.022	5.00	49.43680	9.89693	49.42590	9.89391
300.00	20.022	0.00	0.00616	0.00053	0.00000	0.00000
	20.022	3.00	29.69370	1.97988	29.68200	1.97881
	20.022	6.00	59.38220	3.95929	59.37080	3.95820
	20.022	9.00	89.07030	5.93867	89.05910	5.93757
	20.022	12.00	118.75790	7.91794	116.74770	7.78416
	20.022	10.00	98.96550	9.89690	98.95390	9.89565

Table 5: Integrator No. 1002 Calibration Data

RC	Time	V_{nominal}	$V_{\text{in}} < 0$	V_{out}	$V_{\text{in}} > 0$	V_{out}
0.10	2.022	0.00	0.00304	0.06616	0.00000	0.00000
	2.022	0.02	0.07644	1.66743	0.08312	1.53108
	2.022	0.04	0.15628	3.26404	0.16284	3.12978
	2.022	0.06	0.23646	4.85988	0.24328	4.72540
	2.022	0.08	0.31640	6.45635	0.32374	6.32436
	2.022	0.10	0.39584	8.05751	0.40196	7.92350
	2.022	0.12	0.47584	9.65445	0.48188	9.51730
0.30	2.022	0.00	0.00092	0.03709	0.00000	0.00000
	2.022	0.03	0.19816	1.36291	0.19940	1.29133
	2.022	0.06	0.39634	2.69494	0.39810	2.62173
	2.022	0.09	0.59504	4.02593	0.59692	3.95040
	2.022	0.12	0.79398	5.35405	0.79546	5.28065
	2.022	0.15	0.99280	6.68449	0.99436	6.60937
	2.022	0.18	1.19112	8.01392	1.19286	7.94048
	2.022	0.21	1.38986	9.34293	1.39142	9.27276
1.00	2.022	0.00	0.00062	0.01434	0.00000	0.00000
	2.022	0.10	0.86260	1.74654	0.86128	1.71759
	2.022	0.20	1.72456	3.47765	1.72314	3.44931
	2.022	0.30	2.58640	5.21087	2.58510	5.18127
	2.022	0.40	3.44858	6.94350	3.44680	6.91382
	2.022	0.50	4.31038	8.67520	4.30898	8.64628
3.00	2.022	0.00	0.00128	0.00537	0.00000	0.00000
	2.022	0.30	2.83172	1.89678	2.82888	1.88646
	2.022	0.60	5.66214	3.78837	5.65964	3.77835
	2.022	0.90	8.49218	5.68037	8.48986	5.66995
	2.022	1.20	11.32240	7.57197	11.31954	7.56133
	2.022	1.50	14.15296	9.46358	14.15020	9.45305
10.00	2.022	0.00	0.00128	0.00155	0.00000	0.00000
	2.022	1.00	9.75756	1.96219	9.75374	1.95886
	2.022	2.00	19.51330	3.92264	19.50958	3.91944
	2.022	3.00	29.26900	5.88324	29.26510	5.87982
	2.022	4.00	39.02560	7.84386	39.02200	7.84059
	2.022	5.00	48.78120	9.80447	48.77770	9.80108
30.00	2.022	0.00	0.00136	0.00048	0.00000	0.00000
	2.022	1.00	9.85358	0.66043	9.85012	0.65926
	2.022	2.00	19.70570	1.32033	19.70222	1.31918
	2.022	3.00	29.55780	1.98019	29.55420	1.97905
	2.022	4.00	39.41040	2.64011	39.40710	2.63901
100.00	20.022	0.00	0.00195	0.00166	0.00000	0.00000
	20.022	0.05	0.49585	0.10064	0.49514	0.09735
	20.022	0.10	0.99017	0.19965	0.98663	0.19645
	20.022	0.15	1.48447	0.29866	1.48110	0.29547
	20.022	0.20	1.97882	0.39764	1.97526	0.39448
	20.022	0.25	2.47305	0.49684	2.46971	0.49363
	20.022	0.30	2.96730	0.59584	2.96415	0.59298
	20.022	0.40	3.95608	0.79392	3.95262	0.79067
	20.022	0.50	4.94497	0.99202	4.94117	0.98871
	20.022	0.60	5.93351	1.19002	5.93019	1.18673
	20.022	0.80	7.91042	1.58620	7.90750	1.58296
	20.022	1.00	9.88748	1.98233	9.88459	1.97904
	20.022	1.50	14.83080	2.97272	14.82779	2.96940
	20.022	2.00	19.77400	3.96307	19.77072	3.95983
	20.022	2.50	24.71700	4.95345	24.71390	4.95019
	20.022	3.00	29.65980	5.94375	29.65660	5.94041
	20.022	3.50	34.60310	6.93417	34.59990	6.93083
	20.022	4.00	39.54680	7.92454	39.54330	7.92135
	20.022	4.50	44.49000	8.91498	44.48690	8.91164
	20.022	5.00	49.43290	9.90519	49.42960	9.90191
300.00	20.022	0.00	0.00195	0.00055	0.00000	0.00000
	20.022	3.00	29.68850	1.98072	29.68630	1.97967
	20.022	6.00	59.37720	3.96097	59.37500	3.95997
	20.022	9.00	89.06540	5.94114	89.06300	5.94018
	20.022	12.00	117.26500	7.82330	116.76280	7.78859
	30.023	10.00	98.95650	9.90155	98.95850	9.90010

Table 6. Integrator No. 1003 Calibration Data

RC	Time	V _{nominal}	V _{in < 0}	V _{out}	V _{in > 0}	V _{out}
0.10	2.022	0.00	0.00182	0.06022	0.00000	0.00000
	2.022	0.02	0.07554	1.65946	0.08284	1.53462
	2.022	0.04	0.15582	3.25654	0.16264	3.13317
	2.022	0.06	0.23566	4.85364	0.24206	4.73133
	2.022	0.08	0.31552	6.45233	0.32224	6.32799
	2.022	0.10	0.39550	8.05143	0.40200	7.92538
	2.022	0.12	0.47560	9.64708	0.48264	9.52334
0.30	2.022	0.00	0.00150	0.03327	0.00000	0.00000
	2.022	0.03	0.19770	1.36285	0.19986	1.24949
	2.022	0.06	0.39614	2.69213	0.39854	2.62396
	2.022	0.09	0.59482	4.02136	0.59730	3.95242
	2.022	0.12	0.79326	5.35077	0.79616	5.28153
	2.022	0.15	0.99216	6.67999	0.99488	6.61152
	2.022	0.18	1.19084	8.00837	1.19348	7.93915
	2.022	0.21	1.38956	9.33786	1.39196	9.26832
1.00	2.022	0.00	0.00052	0.01353	0.00000	0.00000
	2.022	0.10	0.86248	1.74366	0.86150	1.71686
	2.022	0.20	1.72462	3.47429	1.72360	3.44707
	2.022	0.30	2.58688	5.20455	2.58560	5.17818
	2.022	0.40	3.44876	6.93526	3.44778	6.90836
	2.022	0.50	4.31074	8.66565	4.31020	8.63911
3.00	2.022	0.00	0.00068	0.00435	0.00000	0.00000
	2.022	0.30	2.83108	1.89679	2.82938	1.88704
	2.022	0.60	5.6146	3.78903	5.65994	3.77930
	2.022	0.90	8.49176	5.68109	8.49012	5.67126
	2.022	1.20	11.32176	7.57289	11.32010	7.56312
	2.022	1.50	14.15224	9.46515	14.15050	9.45516
10.00	2.022	0.00	0.00124	0.00156	0.00000	0.00000
	2.022	1.00	9.75720	1.96094	9.75472	1.95791
	2.022	2.00	19.51312	3.92030	19.51064	3.91727
	2.022	3.00	29.26880	5.87965	29.26620	5.87661
	2.022	4.00	39.02530	7.83923	39.02290	7.83606
	2.022	5.00	48.78110	9.79855	48.77830	9.79538
30.00	2.022	0.00	0.00146	0.00042	0.00000	0.00000
	2.022	1.00	9.85338	0.66027	9.85040	0.65921
	2.022	2.00	19.70576	1.32005	19.70246	1.31899
	2.022	3.00	29.55750	1.97982	29.55420	1.97876
	2.022	4.00	39.41040	2.63964	39.40690	2.63857
100.00	20.022	0.00	0.00161	0.00150	0.00000	0.00000
	20.022	0.05	0.49568	0.10067	0.49255	0.09783
	20.022	0.10	0.99004	0.19983	0.98695	0.19678
	20.022	0.15	1.48440	0.29898	1.48129	0.29597
	20.022	0.20	1.97872	0.39815	1.97543	0.39511
	20.022	0.25	2.47310	0.49727	2.46987	0.49426
	20.022	0.30	2.96747	0.59643	2.96415	0.59340
	20.022	0.40	3.95617	0.79475	3.95300	0.79173
	20.022	0.50	4.94458	0.99306	4.94184	0.99005
	20.022	0.60	5.93337	1.19135	5.93013	1.18827
	20.022	0.80	7.91069	1.58794	7.90734	1.58490
	20.022	1.00	9.88761	1.98454	9.88420	1.98149
	20.022	1.50	14.83085	2.97608	14.82749	2.97301
	20.022	2.00	19.77390	3.96755	19.77050	3.96453
	20.022	2.50	24.71720	4.95905	24.71380	4.95604
	20.022	3.00	29.65980	5.95049	29.65600	5.94747
	20.022	3.50	34.60320	6.94205	34.59980	6.93901
	20.022	4.00	39.54700	7.93358	39.54310	7.93057
	20.022	4.50	44.49010	8.92515	44.48650	8.92208
	20.022	5.00	49.43290	9.91645	49.42940	9.91352
300.00	20.022	0.00	0.00173	0.00053	0.00000	0.00000
	20.022	3.00	29.68930	1.98138	29.68570	1.98038
	20.022	6.00	59.37790	3.96228	59.37410	3.96133
	20.022	9.00	89.06600	5.94321	89.06200	5.94218
	20.022	12.00	118.75360	7.92405	116.74640	7.78965
	30.023	10.00	98.96140	9.90460	98.95760	9.90331

Table 7: Integrator No. 1004 Calibration Data

RC	Time	$V_{nominal}$	$V_{in < 0}$	V_{out}	$V_{in > 0}$	V_{out}
0.10	2.022	0.00	0.00266	0.05990	0.00000	0.00000
	2.022	0.02	0.07732	1.65991	0.08258	1.53829
	2.022	0.04	0.15700	3.26220	0.16234	3.14045
	2.022	0.06	0.23694	4.86202	0.24230	4.74165
	2.022	0.08	0.31652	6.46518	0.32202	6.34389
	2.022	0.10	0.39630	8.06673	0.40176	7.94440
	2.022	0.12	0.47610	9.66907	0.48152	9.54699
0.30	2.022	0.00	0.00100	0.03450	0.00000	0.00000
	2.022	0.03	0.19770	1.36679	0.19956	1.29713
	2.022	0.06	0.39628	2.69820	0.39822	2.63007
	2.022	0.09	0.59520	4.03070	0.59690	3.96172
	2.022	0.12	0.79366	5.36270	0.79558	5.29510
	2.022	0.15	0.99256	6.69468	0.99446	6.62618
	2.022	0.18	1.19108	8.02685	1.19302	7.95911
1.00	2.022	0.00	0.00021	0.01297	0.00000	0.00000
	2.022	0.10	0.86246	1.74847	0.86136	1.72147
	2.022	0.20	1.72434	3.48367	1.72336	3.45711
	2.022	0.30	2.58632	5.21914	2.58550	5.19227
	2.022	0.40	3.44866	6.95420	3.44754	6.92772
	2.022	0.50	4.31050	8.68946	4.30948	8.66265
	2.022	0.00	0.00086	0.00484	0.00000	0.00000
3.00	2.022	0.30	2.83134	1.89962	2.82922	1.88992
	2.022	0.60	5.66166	3.79460	5.65986	3.78508
	2.022	0.90	8.49208	5.68939	8.49014	5.68006
	2.022	1.20	11.32250	7.58418	11.32023	7.57471
	2.022	1.50	14.15278	9.47929	14.15058	9.46953
	2.022	0.00	0.00134	0.00153	0.00000	0.00000
10.00	2.022	1.00	9.75702	1.96582	9.75410	1.96272
	2.022	2.00	19.51272	3.93006	19.50978	3.92700
	2.022	3.00	29.26850	5.89428	29.26540	5.89125
	2.022	4.00	39.02490	7.85871	39.02200	7.85564
	2.022	5.00	48.78060	9.82286	48.77780	9.81984
	2.022	0.00	0.00114	0.00050	0.00000	0.00000
30.00	2.022	1.00	9.85304	0.66170	9.85052	0.66071
	2.022	2.00	19.70502	1.32288	19.70250	1.32185
	2.022	3.00	29.55690	1.98408	29.55440	1.98291
	2.022	4.00	39.40950	2.64531	39.40690	2.64424
	2.022	0.00	0.00138	0.00153	0.00000	0.00000
100.00	2.022	0.05	0.49558	0.10090	0.49320	0.09785
	2.022	0.10	0.98981	0.20026	0.98763	0.19726
	2.022	0.15	1.48413	0.29967	1.48200	0.29663
	2.022	0.20	1.97849	0.39905	1.97638	0.39603
	2.022	0.25	2.47272	0.49843	2.47070	0.49543
	2.022	0.30	2.96703	0.59780	2.96502	0.59481
	2.022	0.40	3.95563	0.79659	3.95371	0.79363
	2.022	0.50	4.94416	0.99536	4.94229	0.99236
	2.022	0.60	5.93268	1.19413	5.93093	1.19113
	2.022	0.80	7.90984	1.59167	7.90810	1.58868
	2.022	1.00	9.88678	1.98914	9.88511	1.98615
	2.022	1.50	14.82986	2.98299	14.82816	2.98003
	2.022	2.00	19.77303	3.97689	19.77113	3.97383
	2.022	2.50	24.71600	4.97070	24.71430	4.96775
	2.022	3.00	29.65870	5.96446	29.65720	5.96154
	2.022	3.50	34.60210	6.95838	34.60040	6.95539
	2.022	4.00	39.54570	7.95234	39.54390	7.94935
	2.022	4.50	44.48870	8.94608	44.48730	8.94321
	2.022	5.00	49.43140	9.93973	49.43020	9.93691
300.00	2.022	0.00	0.00115	0.00054	0.00000	0.00000
	2.022	3.00	29.68850	1.98786	29.68650	1.98683
	2.022	6.00	59.37690	3.97528	59.37480	3.97429
	2.022	9.00	89.06470	5.96257	89.06290	5.96167
	2.022	12.00	118.75260	7.94987	116.76040	7.81632
	30.023	10.00	98.96080	9.93734	98.95760	9.93544

B Time Constant Linear Regression Results

These are the time constant values obtained by running RLONE on the data points from Appendix A. There are four tables, one for each INTEGRATOR. Three values are listed for each of the eight **Time Constants**, representing fits to three different ranges of data. One is for negative input voltages ($V_{in} < 0$), the next is for positive input voltages ($V_{in} > 0$), and the final one is fitted to the entire range of values ($V_{in} \neq 0$).

The fit was made to the line $V_{out} = M \times (V_{in} \times T) + B$. Thus, the **Time Constant** shown is actually the negative reciprocal of the slope. The **Offset** corresponds to the intercept times the negative of the **Time Constant**. The last column is the **Sum of Residuals Squared**, in units of **square volts**. Section 2.3 contains a quick summary of the **Time Constants** in Table 1 on page 4.

Table 8: Integrator No. 1001 Time Constant Data

Fit for:	RC [msec]	Drift [mV-sec]	Residual Sq. [V ²]
0.1 $V_{in} < 0$	0.10128	-0.00449	0.1157E-02
0.1 $V_{in} > 0$	0.10110	-0.00564	0.5299E-04
0.1 $V_{in} \neq 0$	0.10127	-0.00457	0.1356E-02
0.3 $V_{in} < 0$	0.30246	-0.00162	0.4223E-04
0.3 $V_{in} > 0$	0.30264	-0.00527	0.2849E-04
0.3 $V_{in} \neq 0$	0.30282	-0.00394	0.1811E-03
1.0 $V_{in} < 0$	1.00849	-0.00254	0.6811E-05
1.0 $V_{in} > 0$	1.00866	-0.00386	0.3593E-05
1.0 $V_{in} \neq 0$	1.00868	-0.00364	0.1160E-04
3.0 $V_{in} < 0$	3.03114	-0.00404	0.5045E-06
3.0 $V_{in} > 0$	3.03125	-0.00144	0.3546E-06
3.0 $V_{in} \neq 0$	3.03101	-0.00306	0.1220E-05
10.0 $V_{in} < 0$	10.08302	-0.00645	0.1938E-06
10.0 $V_{in} > 0$	10.08283	-0.00347	0.4757E-07
10.0 $V_{in} \neq 0$	10.08272	-0.00441	0.2877E-06
30.0 $V_{in} < 0$	30.24905	-0.00471	0.1104E-07
30.0 $V_{in} > 0$	30.25040	-0.00347	0.1020E-07
30.0 $V_{in} \neq 0$	30.24941	-0.00520	0.2393E-07
100.0 $V_{in} < 0$	100.01691	-0.03964	0.1729E-06
100.0 $V_{in} > 0$	100.01614	-0.04675	0.2364E-07
100.0 $V_{in} \neq 0$	100.01709	-0.04198	0.2265E-06
300.0 $V_{in} < 0$	300.30704	-0.04954	0.1869E-08
300.0 $V_{in} > 0$	300.28298	-0.12349	0.9518E-07
300.0 $V_{in} \neq 0$	300.30134	-0.02729	0.1776E-06

Table 9: Integrator No. 1002 Time Constant Data

Fit for:	RC [msec]	Drift [mV-sec]	Residual Sq. [V ²]
0.1 $V_{in} < 0$	0.10110	-0.01373	0.1242E-03
0.1 $V_{in} > 0$	0.10096	-0.01401	0.7402E-03
0.1 $V_{in} \neq 0$	0.10105	-0.01347	0.9130E-03
0.3 $V_{in} < 0$	0.30205	-0.01195	0.2663E-04
0.3 $V_{in} > 0$	0.30205	-0.01341	0.1797E-04
0.3 $V_{in} \neq 0$	0.30216	-0.01268	0.6109E-04
1.0 $V_{in} < 0$	1.00610	-0.01261	0.9752E-06
1.0 $V_{in} > 0$	1.00611	-0.01367	0.3915E-06
1.0 $V_{in} \neq 0$	1.00619	-0.01318	0.1876E-05
3.0 $V_{in} < 0$	3.02519	-0.01234	0.1411E-06
3.0 $V_{in} > 0$	3.02534	-0.01289	0.1915E-07
3.0 $V_{in} \neq 0$	3.02530	-0.01303	0.2160E-06
10.0 $V_{in} < 0$	10.06160	-0.01261	0.9849E-08
10.0 $V_{in} > 0$	10.06177	-0.01229	0.3231E-08
10.0 $V_{in} \neq 0$	10.06166	-0.01296	0.1942E-07
30.0 $V_{in} < 0$	30.18876	-0.01381	0.2493E-09
30.0 $V_{in} > 0$	30.18787	-0.01508	0.2935E-09
30.0 $V_{in} \neq 0$	30.18863	-0.01371	0.2090E-08
100.0 $V_{in} < 0$	99.93402	-0.12960	0.5426E-07
100.0 $V_{in} > 0$	99.93471	-0.12924	0.5368E-06
100.0 $V_{in} \neq 0$	99.93434	-0.13052	0.5957E-06
300.0 $V_{in} < 0$	300.12435	0.03281	0.4820E-06
300.0 $V_{in} > 0$	300.13753	-0.25037	0.1937E-06
300.0 $V_{in} \neq 0$	300.15500	-0.14133	0.9855E-06

Table 10: Integrator No. 1003 Time Constant Data

Fit for:	RC [msec]	Drift [mV-sec]	Residual Sq. [V ²]
0.1 $V_{in} < 0$	0.10121	-0.01492	0.3941E-04
0.1 $V_{in} > 0$	0.10115	-0.01172	0.2153E-03
0.1 $V_{in} \neq 0$	0.10095	-0.01314	0.8420E-03
0.3 $V_{in} < 0$	0.30221	-0.01250	0.6338E-05
0.3 $V_{in} > 0$	0.30124	-0.02049	0.1081E-02
0.3 $V_{in} \neq 0$	0.30232	-0.01394	0.1841E-02
1.0 $V_{in} < 0$	1.00728	-0.01229	0.3167E-06
1.0 $V_{in} > 0$	1.00734	-0.01243	0.4656E-06
1.0 $V_{in} \neq 0$	1.00732	-0.01251	0.8421E-06
3.0 $V_{in} < 0$	3.02464	-0.01280	0.8978E-08
3.0 $V_{in} > 0$	3.02470	-0.01321	0.3599E-08
3.0 $V_{in} \neq 0$	3.02470	-0.01317	0.2773E-07
10.0 $V_{in} < 0$	10.06761	-0.01275	0.3205E-08
10.0 $V_{in} > 0$	10.06777	-0.01225	0.3163E-08
10.0 $V_{in} \neq 0$	10.06766	-0.01296	0.1219E-07
30.0 $V_{in} < 0$	30.19350	-0.01220	0.1900E-09
30.0 $V_{in} > 0$	30.19316	-0.01383	0.1051E-09
30.0 $V_{in} \neq 0$	30.19374	-0.01273	0.1410E-08
100.0 $V_{in} < 0$	99.82003	-0.12437	0.2862E-07
100.0 $V_{in} > 0$	99.81884	-0.11384	0.6370E-07
100.0 $V_{in} \neq 0$	99.81861	-0.11722	0.1593E-06
300.0 $V_{in} < 0$	300.07418	-0.11950	0.7313E-09
300.0 $V_{in} > 0$	300.06205	-0.14207	0.2126E-07
300.0 $V_{in} \neq 0$	300.07006	-0.10090	0.3939E-07

Table 11: Integrator No. 1004 Time Constant Data

Fit for:	RC [msec]	Drift [mV-sec]	Residual Sq. [V ²]
0.1 $V_{in} < 0$	0.10068	-0.01077	0.1923E-04
0.1 $V_{in} > 0$	0.10073	-0.01206	0.9425E-05
0.1 $V_{in} \neq 0$	0.10080	-0.01158	0.1298E-03
0.3 $V_{in} < 0$	0.30160	-0.01242	0.2093E-05
0.3 $V_{in} > 0$	0.30157	-0.01218	0.3476E-05
0.3 $V_{in} \neq 0$	0.30157	-0.01221	0.6331E-05
1.0 $V_{in} < 0$	1.00449	-0.01262	0.3610E-06
1.0 $V_{in} > 0$	1.00447	-0.01234	0.1142E-06
1.0 $V_{in} \neq 0$	1.00446	-0.01241	0.5187E-06
3.0 $V_{in} < 0$	3.02023	-0.01238	0.5235E-07
3.0 $V_{in} > 0$	3.02018	-0.01262	0.2095E-07
3.0 $V_{in} \neq 0$	3.02022	-0.01234	0.8228E-07
10.0 $V_{in} < 0$	10.04265	-0.01342	0.3408E-08
10.0 $V_{in} > 0$	10.04260	-0.01162	0.5118E-08
10.0 $V_{in} \neq 0$	10.04250	-0.01238	0.2358E-07
30.0 $V_{in} < 0$	30.12842	-0.01299	0.1190E-09
30.0 $V_{in} > 0$	30.13008	-0.01122	0.1065E-07
30.0 $V_{in} \neq 0$	30.12880	-0.01348	0.1526E-07
100.0 $V_{in} < 0$	99.58312	-0.12886	0.4974E-07
100.0 $V_{in} > 0$	99.58325	-0.13084	0.2291E-07
100.0 $V_{in} \neq 0$	99.58334	-0.13005	0.7471E-07
300.0 $V_{in} < 0$	299.10117	-0.15598	0.2306E-08
300.0 $V_{in} > 0$	299.06793	-0.21119	0.7346E-07
300.0 $V_{in} \neq 0$	299.08931	-0.10134	0.2055E-06

C Deviation from Straight Line: Data

These are the differences between the fitted and measured values for each point. This is the data from which the graphs in Appendix D were made. They are from the formula:

$$\Delta Y = Y_{\text{measured}} - Y_{\text{predicted}}$$

or, as it was actually calculated:

$$\Delta V_{\text{out}} = V_{\text{out}} - (\text{Slope} \times (V_{\text{in}} \cdot T) + \text{Intercept})$$

There are two halves to this chart. The first half uses those values of V_{out} which are greater than zero, corresponding to $V_{\text{in}} < 0$. The next two columns are ΔV_{out} calculated with two different values of *Slope* and *Intercept*. The first is from the **Local** fit, which was fitted to $V_{\text{in}} < 0$, and the second is the **Global** fit, which included all values of $V_{\text{in}} \neq 0$. The right half of the table is analogous, except that it is for $V_{\text{in}} > 0$ ($V_{\text{out}} < 0$). All values are in *volts*.

Table 12 Integrator No. 1001 Deviation from Fit

V_{out} [Volts]	ΔV_{out} Volts		V_{out} [Volts]	ΔV_{out} Volts	
	$V_{in} < 0$	$V_{in} \neq 0$		$V_{in} > 0$	$V_{in} \neq 0$
$- RC = 0.1 \text{ msec}$ —					
-1.65646	-0.57920E-02	-0.67461E-02	-1.53180	+0.44136E-02	+0.12401E-01
+3.25149	+0.24025E-01	-0.22916E-01	-3.12846	-0.22463E-02	+0.30715E-02
+4.84755	-0.12608E-01	-0.13878E-01	-4.72338	-0.39663E-02	-0.13229E-02
-6.44186	-0.94654E-02	-0.10892E-01	-6.31740	+0.13650E-04	-0.25457E-04
-8.03882	-0.96618E-02	-0.11247E-01	-7.91475	-0.17364E-02	-0.44540E-02
+9.63280	+0.14313E-01	-0.12574E-01	-9.50749	-0.31237E-02	-0.22758E-02
$- RC = 0.3 \text{ msec}$ —					
+1.36118	-0.40757E-02	-0.10114E-01	-1.29301	-0.26443E-02	+0.98075E-03
+2.68763	+0.16498E-02	-0.28183E-02	-2.61916	+0.30372E-02	-0.58706E-02
+4.01613	+0.18043E-02	-0.10847E-02	-3.94585	-0.15759E-02	-0.47164E-03
+5.34129	-0.19613E-02	-0.64751E-03	-5.27267	-0.16985E-02	-0.29554E-02
+6.66891	-0.29739E-02	+0.32372E-02	-6.60082	+0.35009E-04	-0.50343E-03
+7.99587	-0.17543E-02	-0.92178E-04	-7.92772	+0.14923E-02	-0.11711E-02
+9.32198	-0.19843E-02	+0.14390E-02	-9.25372	-0.21636E-02	-0.32708E-02
$- RC = 1.0 \text{ msec}$ —					
+1.74156	-0.88608E-03	-0.12343E-03	-1.71467	-0.19979E-03	-0.15679E-04
+3.46984	-0.27378E-03	-0.16321E-03	-3.44267	+0.88224E-03	+0.10321E-02
+5.19781	-0.16510E-02	-0.17622E-02	-5.17083	-0.14032E-02	-0.12875E-02
+6.92596	-0.94974E-03	-0.73548E-03	-6.89932	+0.87277E-03	-0.95406E-03
+8.65464	-0.15246E-02	+0.20640E-02	-8.62648	-0.21216E-03	-0.16509E-03
$- RC = 3.0 \text{ msec}$ —					
-1.89316	+0.25382E-03	-0.49596E-03	-1.88332	-0.17489E-03	-0.56026E-03
+3.78142	+0.35702E-04	-0.19684E-03	-3.77164	-0.21420E-04	-0.21441E-03
+5.66969	-0.38588E-03	-0.30574E-03	-5.65992	+0.11098E-03	+0.24679E-04
+7.55757	-0.31692E-03	-0.31775E-03	-7.54789	+0.41716E-03	+0.48037E-03
+9.44608	+0.43540E-03	-0.35361E-03	-9.43622	-0.37042E-03	-0.15775E-03
$- RC = 10.0 \text{ msec}$ —					
+1.95795	-0.15748E-03	-0.13411E-04	-1.95490	-0.95774E-05	-0.81479E-04
+3.91444	+0.23831E-04	-0.10969E-03	-3.91133	-0.81987E-04	-0.13254E-03
+5.87087	+0.36573E-03	-0.39338E-03	-5.86775	+0.76196E-04	+0.46983E-04
+7.82743	-0.17709E-03	-0.20766E-03	-7.82432	+0.14454E-03	+0.13667E-03
+9.78383	-0.57704E-04	-0.14649E-03	-9.78064	-0.11868E-03	-0.10520E-03
$- RC = 90.0 \text{ msec}$ —					
+0.65907	-0.70183E-05	-0.15373E-04	-0.65799	-0.48330E-04	-0.83989E-04
+1.31760	-0.33355E-04	-0.33872E-04	-1.31655	+0.84385E-04	-0.70284E-04
+1.97615	+0.87314E-04	-0.94632E-04	-1.97510	-0.24226E-04	-0.16777E-04
+2.63474	-0.47473E-04	-0.32315E-04	-2.63369	-0.12416E-04	-0.16588E-04
$- RC = 100.0 \text{ msec}$ —					
+0.10047	-0.74680E-04	+0.51465E-04	-0.09742	+0.22373E-04	-0.69139E-04
+0.19937	-0.20354E-03	-0.22658E-03	-0.19640	-0.14862E-04	+0.30965E-04
+0.29838	-0.19076E-03	-0.16790E-03	-0.29534	-0.19934E-04	-0.64820E-04
+0.39734	-0.79516E-04	-0.10220E-03	-0.39430	+0.32728E-04	+0.76674E-04
+0.49629	-0.63512E-04	-0.86015E-04	-0.49327	-0.26537E-04	-0.16470E-04
+0.59522	+0.23477E-03	-0.21245E-03	-0.59220	-0.17598E-05	+0.40307E-04
+0.79313	-0.10157E-03	-0.12354E-03	-0.79014	-0.81835E-05	-0.32003E-04
+0.99106	-0.85608E-04	-0.10722E-03	-0.98801	+0.29368E-04	+0.67675E-04
+1.18894	-0.35566E-04	-0.56822E-04	-1.18593	+0.40943E-04	+0.77370E-04
+1.58475	+0.32443E-04	-0.11899E-04	-1.58178	-0.23981E-04	+0.86863E-05
+1.98057	-0.11662E-04	-0.31494E-04	-1.97757	-0.36913E-04	-0.80047E-05
+2.97013	-0.58258E-05	-0.23877E-04	-2.96713	-0.91067E-05	+0.10402E-04
+3.95968	+0.24042E-04	-0.77722E-05	-3.95662	+0.38653E-04	+0.48763E-04
+4.94924	+0.41889E-04	-0.27400E-04	-4.94625	-0.59593E-04	-0.58882E-04
+5.93869	+0.11794E-04	-0.91372E-06	-5.93569	-0.11880E-04	-0.20568E-04
+6.92825	+0.11625E-04	-0.69781E-06	-6.92529	-0.64111E-04	-0.82198E-04
+7.91789	-0.11381E-04	-0.22350E-05	-7.91492	+0.13808E-04	-0.13680E-04
+8.90746	-0.18825E-04	-0.26191E-04	-8.90450	-0.18423E-04	-0.55310E-04
+9.89693	-0.28920E-04	-0.34505E-04	-9.89391	+0.79308E-04	-0.33023E-04
$- RC = 900.0 \text{ msec}$ —					
-1.97988	-0.16314E-04	-0.20198E-04	-1.97881	-0.11139E-03	-0.87976E-04
-3.95929	-0.90308E-05	-0.79721E-05	-3.95820	-0.61862E-04	-0.14021E-03
-5.93867	-0.31044E-04	-0.75850E-05	-5.93757	+0.22178E-03	-0.17910E-03
-7.91794	-0.23608E-04	-0.99806E-04	-7.78416	-0.17251E-03	-0.32807E-03

Table 13: Integrator No. 1002 Deviation from Fit

V_{out} [Volts]	ΔV_{out} [Volts]	$V_{in} < 0$	$V_{in} \neq 0$	V_{out} [Volts]	ΔV_{out} [Volts]	$V_{in} > 0$	$V_{in} \neq 0$
$- RC = 0.1 \text{ msec}$							
-1.66743	-0.28239E-02	-0.45732E-02	-1.53108	-0.51426E-02	-0.11578E-02		
+3.26404	-0.26339E-02	-0.35931E-02	-3.12978	-0.72317E-02	-0.46689E-02		
+4.85988	-0.51261E-02	-0.49604E-02	-4.72540	-0.81792E-02	+0.93072E-02		
-6.45635	-0.74561E-02	-0.80815E-02	-6.32436	-0.20651E-01	-0.20343E-01		
-8.05751	-0.49039E-02	-0.34924E-02	-7.92350	-0.11920E-01	-0.13623E-01		
-9.65445	+0.18439E-02	-0.35930E-03	-9.51730	-0.51035E-02	-0.82316E-02		
$- RC = 0.3 \text{ msec}$							
-1.36291	-0.31867E-02	-0.31054E-02	-1.29133	-0.89199E-03	-0.10542E-02		
-2.69494	-0.21756E-02	-0.73997E-03	-2.62173	-0.11433E-02	-0.31858E-03		
+4.02593	+0.30170E-02	+0.20656E-02	-3.95040	+0.11386E-02	-0.21160E-02		
+5.35405	-0.61830E-03	-0.10849E-02	-5.28065	-0.33811E-04	+0.45974E-03		
+6.68449	-0.11303E-02	-0.11123E-02	-6.60937	-0.27337E-02	-0.27425E-02		
-8.01392	+0.69491E-03	+0.11961E-02	-7.94048	+0.43349E-03	-0.41424E-04		
-9.34293	-0.71152E-03	-0.27406E-03	-9.27276	-0.26351E-02	-0.35939E-02		
$- RC = 1.0 \text{ msec}$							
-1.74654	+0.40423E-03	-0.60798E-05	-1.71759	-0.24482E-03	+0.10562E-03		
-3.47765	-0.80176E-03	-0.10571E-02	-3.44931	+0.13298E-03	+0.34571E-03		
+5.21087	-0.34341E-03	+0.24298E-03	-5.18127	+0.47176E-03	+0.54675E-03		
+6.94350	-0.21528E-03	+0.26984E-03	-6.91382	-0.30199E-03	-0.36469E-03		
+8.67520	-0.79157E-04	+0.13032E-03	-8.64628	-0.21082E-04	-0.22154E-03		
$- RC = 3.0 \text{ msec}$							
-1.89678	+0.13899E-04	-0.14521E-03	-1.88646	-0.25629E-04	-0.46963E-04		
-3.78837	-0.21422E-03	-0.30454E-03	-3.77835	+0.35927E-04	-0.39608E-04		
+5.68037	-0.22166E-03	+0.20011E-03	-5.66995	-0.26571E-04	+0.55262E-04		
+7.57197	+0.13722E-03	+0.18446E-03	-7.56133	-0.12370E-03	-0.69999E-04		
+9.46358	-0.16447E-03	-0.48440E-04	-9.45305	-0.41024E-04	-0.11973E-03		
$- RC = 10.0 \text{ msec}$							
+1.96219	+0.37229E-04	+0.14144E-04	-1.95886	+0.17243E-04	-0.27931E-04		
-3.92264	-0.46511E-04	-0.57905E-04	-3.91944	-0.42045E-04	-0.65785E-04		
-5.88324	+0.27787E-04	+0.28085E-04	-5.87982	-0.34360E-04	+0.32052E-04		
+7.84386	-0.58780E-04	-0.46791E-04	-7.84059	-0.19126E-05	+0.17216E-04		
+9.80447	+0.45614E-04	+0.69295E-04	-9.80108	+0.66473E-06	+0.41226E-04		
$- RC = 30.0 \text{ msec}$							
+0.66043	-0.61610E-05	-0.56925E-05	-0.65926	-0.68724E-05	-0.35657E-04		
+1.32033	-0.12922E-04	-0.10549E-04	-1.31918	-0.14095E-04	-0.19240E-05		
-1.98019	-0.66560E-05	-0.11871E-04	-1.97905	+0.68993E-05	+0.24578E-05		
+2.64011	+0.27704E-06	-0.77794E-05	-2.63901	-0.48393E-06	-0.21540E-04		
$- RC = 100.0 \text{ msec}$							
+0.10064	-0.14903E-05	-0.10374E-04	-0.09735	+0.55846E-03	+0.54601E-03		
-0.19965	-0.29586E-04	-0.38153E-04	-0.19645	-0.71126E-04	-0.83207E-04		
-0.29866	-0.53675E-04	-0.61924E-04	-0.29547	-0.23661E-04	-0.35376E-04		
+0.39764	-0.11778E-03	-0.12571E-03	-0.39448	-0.28305E-04	-0.39653E-04		
+0.49684	+0.62155E-04	+0.54540E-04	-0.49363	-0.11485E-03	-0.12583E-03		
+0.59584	+0.38084E-04	+0.30786E-04	-0.59298	-0.40339E-03	-0.41401E-03		
+0.79392	-0.13843E-04	-0.71792E-05	-0.79067	-0.52629E-04	-0.62511E-04		
+0.99202	-0.12436E-04	-0.18466E-04	-0.98871	-0.35837E-04	-0.44985E-04		
-1.19002	-0.68593E-04	-0.73988E-04	-1.18673	+0.95120E-04	+0.86706E-04		
+1.58620	+0.33155E-04	+0.29028E-04	-1.58296	+0.20778E-04	+0.13831E-04		
+1.98233	+0.54849E-04	+0.51991E-04	-1.97904	+0.52359E-04	-0.46878E-04		
+2.97272	-0.39850E-04	+0.40162E-04	-2.96940	+0.66479E-04	-0.64664E-04		
+3.96307	-0.88923E-05	+0.12376E-04	-3.95983	-0.43497E-04	-0.41645E-04		
+4.95345	-0.48005E-04	+0.54661E-04	-4.95019	-0.33385E-04	-0.27865E-04		
+5.94375	-0.47189E-04	-0.57015E-04	-5.94041	+0.20559E-04	+0.29745E-04		
+6.93417	-0.66196E-04	-0.79194E-04	-6.93083	-0.52865E-05	-0.75659E-05		
+7.92454	-0.44937E-04	-0.28768E-04	-7.92135	-0.11110E-03	-0.94578E-04		
+8.91498	+0.14106E-04	-0.33446E-04	-8.91164	-0.53162E-04	+0.73349E-04		
+9.90519	-0.96746E-04	-0.74235E-04	-9.90191	-0.57106E-04	+0.80959E-04		
$- RC = 300.0 \text{ msec}$							
+1.98072	+0.23979E-03	-0.13815E-03	-1.97967	-0.14838E-03	-0.99681E-04		
-3.96097	-0.11309E-03	-0.28878E-03	-3.95997	-0.67520E-04	-0.29031E-03		
+5.94114	-0.51261E-03	-0.48606E-03	-5.94018	-0.32673E-03	-0.34425E-03		
+7.82330	+0.38586E-03	-0.60453E-03	-7.78859	-0.24573E-03	-0.33576E-03		

Table 14: Integrator No. 1003 Deviation from Fit

V_{out} Volts	ΔV_{out} Volts		V_{out} Volts	ΔV_{out} Volts	
	$V_{in} < 0$	$V_{in} \neq 0$		$V_{in} > 0$	$V_{in} \neq 0$
$- RC = 0.1 \text{ msec}$					
+1.65946	+0.28858E-02	-0.16252E-01	-1.53462	+0.54935E-02	-0.55216E-02
+3.25654	-0.38892E-02	-0.53459E-02	-3.13317	+0.21546E-02	-0.57002E-02
+4.85364	-0.18537E-02	+0.32733E-02	-4.73133	-0.83906E-02	-0.13100E-01
+6.45233	+0.13722E-02	+0.23900E-02	-6.32799	-0.22433E-02	-0.37772E-02
+8.05143	-0.26107E-02	-0.48679E-03	-7.92538	-0.52218E-02	-0.35969E-02
+9.64708	-0.19982E-02	-0.92172E-02	-9.52334	+0.88209E-02	+0.13639E-01
$- RC = 0.3 \text{ msec}$					
+1.36285	-0.12657E-02	-0.55325E-02	-1.24949	+0.24003E-01	-0.41119E-01
-2.69213	+0.30948E-03	-0.34743E-02	-2.62396	-0.16876E-01	-0.45240E-02
+4.02136	+0.22887E-03	-0.30712E-02	-3.95242	-0.11208E-01	-0.36220E-02
+5.35077	-0.19340E-02	-0.88295E-03	-5.28153	-0.55191E-02	-0.27012E-02
+6.67999	-0.37146E-03	-0.19613E-02	-6.61152	-0.16496E-02	-0.35967E-02
+8.00837	-0.55915E-03	-0.24083E-02	-7.93915	+0.37744E-02	-0.29349E-02
+9.33786	-0.64740E-03	-0.20127E-02	-9.26832	-0.68530E-02	-0.46156E-02
$- RC = 1.0 \text{ msec}$					
+1.74366	+0.12835E-03	-0.20816E-04	-1.71686	+0.60801E-04	-0.15472E-04
+3.47429	+0.11039E-03	+0.29944E-04	-3.44707	+0.31539E-03	-0.30442E-03
+5.20455	-0.51846E-03	-0.53017E-03	-5.17818	-0.53075E-03	-0.50736E-03
+6.93526	+0.65496E-04	+0.12249E-03	-6.90836	-0.85574E-04	-0.27831E-04
+8.66565	+0.12872E-03	+0.25442E-03	-8.63911	+0.27134E-03	+0.36345E-03
$- RC = 3.0 \text{ msec}$					
+1.89679	-0.45247E-04	-0.12995E-03	-1.88704	+0.21976E-04	-0.35201E-04
+3.78903	-0.59372E-04	-0.12206E-04	-3.77930	-0.19847E-04	-0.66221E-05
+5.68109	+0.37471E-04	+0.27838E-04	-5.67126	-0.15698E-04	-0.24736E-05
+7.57289	-0.43876E-04	-0.15981E-04	-7.56312	-0.45249E-04	-0.32024E-04
+9.46515	+0.13891E-04	+0.79322E-04	-9.45516	+0.25969E-04	+0.39193E-04
$- RC = 10.0 \text{ msec}$					
+1.96094	+0.16961E-04	+0.58405E-05	-1.95791	+0.62370E-06	-0.48507E-04
+3.92030	-0.22563E-04	-0.23952E-04	-3.91727	+0.90082E-05	-0.18714E-04
+5.87965	-0.23885E-04	-0.15543E-04	-5.87661	-0.34909E-04	-0.41224E-04
+7.83923	+0.40103E-04	+0.58177E-04	-7.83606	+0.40129E-04	+0.55224E-04
+9.79855	-0.15320E-04	-0.12485E-04	-9.79538	-0.15922E-04	-0.20580E-04
$- RC = 30.0 \text{ msec}$					
+0.66027	-0.42355E-05	-0.80696E-05	-0.65921	+0.15168E-05	+0.25285E-04
+1.32005	-0.10500E-04	-0.17561E-04	-1.31899	+0.22525E-05	+0.13347E-04
+1.97982	-0.76232E-05	+0.58067E-05	-1.97876	-0.84417E-05	-0.10021E-04
+2.63964	-0.19362E-05	+0.14922E-05	-2.63857	+0.51541E-05	-0.90996E-05
$- RC = 100.0 \text{ msec}$					
+0.10067	+0.74735E-07	+0.70273E-04	-0.09783	-0.17312E-03	-0.20676E-03
+0.19983	+0.85869E-06	+0.69646E-04	-0.19678	-0.45298E-04	+0.11890E-04
+0.29898	-0.83573E-05	+0.59019E-04	-0.29597	+0.11684E-04	-0.21495E-04
+0.39815	-0.10450E-04	+0.76416E-04	-0.39511	-0.12046E-04	-0.44997E-04
+0.49727	-0.32778E-04	+0.31778E-04	-0.49426	+0.14399E-04	-0.18324E-04
+0.59643	-0.34000E-04	+0.29145E-04	-0.59340	-0.18750E-04	-0.13744E-04
+0.79475	-0.28420E-04	+0.31903E-04	-0.79173	-0.35623E-04	+0.35856E-05
+0.99306	+0.25328E-04	+0.82831E-04	-0.99005	+0.60489E-04	-0.28909E-04
+1.19135	-0.17145E-04	+0.37537E-04	-1.18827	+0.75034E-04	+0.43911E-04
+1.58794	-0.39939E-04	+0.91003E-05	-1.58490	+0.40493E-04	-0.10284E-04
+1.98454	+0.27499E-04	-0.70897E-04	-1.98149	-0.24253E-04	-0.53548E-04
+2.97608	+0.47547E-04	+0.76841E-04	-2.97301	-0.24517E-05	-0.29463E-04
+3.96755	-0.35707E-04	+0.50895E-04	-3.96453	-0.36814E-04	-0.61541E-04
+4.95905	+0.37204E-05	-0.48039E-05	-4.95604	-0.30074E-05	-0.25449E-04
+5.95049	+0.52141E-04	+0.39121E-04	-5.94747	-0.10984E-03	-0.13000E-03
+6.94205	+0.60097E-04	-0.32971E-04	-6.93901	-0.57439E-05	-0.23617E-04
+7.93358	-0.42180E-04	-0.83412E-04	-7.93057	-0.21937E-04	-0.37525E-04
+8.92515	+0.35950E-04	-0.19387E-04	-8.92208	+0.31928E-04	+0.18625E-04
+9.91645	-0.95745E-04	-0.16519E-03	-9.91352	+0.55501E-04	-0.44483E-04
$- RC = 300.0 \text{ msec}$					
+1.98138	+0.77120E-05	-0.42493E-04	-1.98038	-0.39549E-04	-0.44790E-04
-3.96228	-0.19635E-04	-0.12052E-04	-3.96133	+0.45313E-05	-0.35990E-04
-5.94321	-0.16380E-04	-0.32349E-05	-5.94218	+0.11525E-03	-0.93828E-04
+7.92405	-0.42428E-05	-0.51056E-04	-7.78965	-0.79973E-04	-0.15071E-03

Table 15: Integrator No. 1004 Deviation from Fit

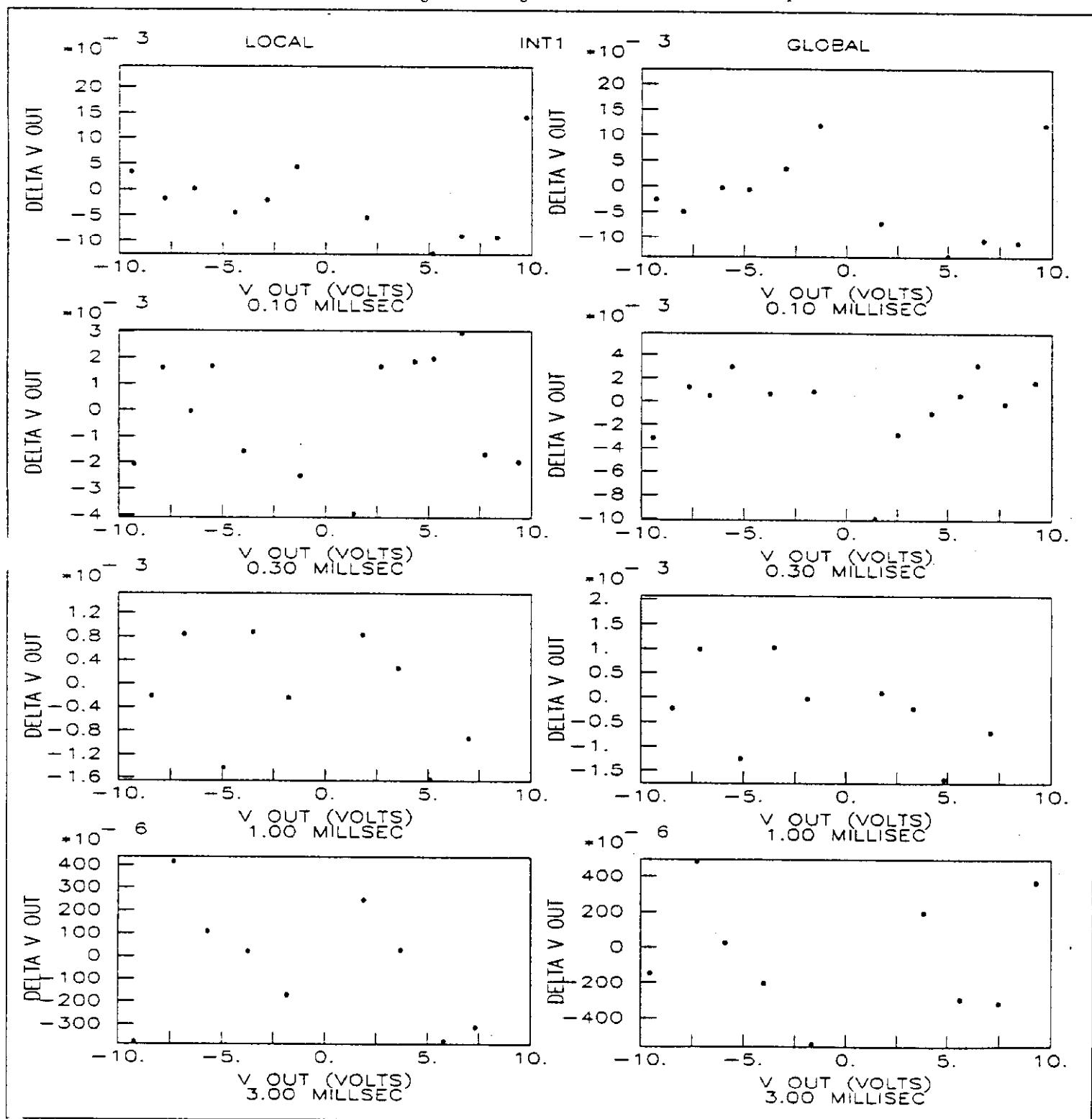
V_{out} (Volts)	ΔV_{out} Volts		V_{out} (Volts)	ΔV_{out} Volts	
	$V_{in} < 0$	$V_{in} \neq 0$		$V_{in} > 0$	$V_{in} \neq 0$
$- RC = 0.1 \text{ msec}$					
+1.65991	+0.86401E-04	-0.59733E-02	-1.53829	-0.34937E-03	-0.33445E-02
+3.26220	+0.21285E-02	-0.20262E-02	-3.14045	-0.14499E-02	-0.11321E-02
-4.86202	-0.35211E-02	-0.57645E-02	-4.74165	+0.24243E-02	-0.38917E-02
+6.46518	+0.13993E-02	+0.10586E-02	-6.34389	+0.44079E-03	+0.79691E-03
+8.06673	+0.69305E-03	+0.22598E-02	-7.94440	-0.58878E-03	-0.16667E-03
+9.66907	+0.37512E-03	-0.38498E-02	-9.54699	-0.94175E-03	-0.28091E-02
$- RC = 0.3 \text{ msec}$					
+1.36679	+0.18058E-03	+0.74099E-03	-1.29713	+0.51340E-03	+0.41392E-03
+2.69820	+0.26180E-03	+0.68977E-03	-2.63007	-0.42899E-03	-0.52847E-03
+4.03070	-0.84642E-03	-0.55112E-03	-3.96172	+0.52723E-04	-0.46757E-04
-5.36270	+0.62931E-03	+0.79225E-03	-5.29510	-0.11956E-02	-0.12951E-02
+6.69468	-0.86483E-03	-0.83454E-03	-6.62618	+0.11971E-02	+0.10977E-02
+8.02685	-0.37865E-03	+0.27653E-03	-7.95911	-0.40575E-03	-0.50523E-03
+9.35902	+0.13103E-04	-0.22157E-03	-9.29090	+0.70057E-04	-0.29423E-04
$- RC = 1.0 \text{ msec}$					
+1.74847	-0.19262E-03	-0.35784E-04	-1.72147	-0.16421E-03	-0.11167E-03
+3.48367	+0.75858E-04	+0.18088E-03	-3.45711	-0.26816E-03	-0.30344E-03
+5.21914	+0.41304E-03	+0.46624E-03	-5.19227	+0.61279E-04	+0.43283E-04
+6.95420	-0.38444E-03	-0.38308E-03	-6.92772	-0.10058E-03	-0.10130E-03
+8.68946	+0.24565E-04	-0.25893E-04	-8.66265	+0.56263E-04	+0.72816E-04
$- RC = 3.0 \text{ msec}$					
+1.89962	-0.19922E-04	-0.12967E-04	-1.88992	+0.54386E-04	+0.12206E-03
+3.79460	+0.10206E-03	+0.10274E-03	-3.78508	-0.19848E-05	+0.40594E-04
+5.68939	-0.32911E-04	-0.38505E-04	-5.68006	-0.11937E-03	-0.10189E-03
+7.58418	-0.16788E-03	-0.17975E-03	-7.57471	-0.33967E-04	-0.41579E-04
+9.47929	+0.11088E-03	+0.92736E-04	-9.46953	+0.55508E-04	+0.22801E-04
$- RC = 10.0 \text{ msec}$					
+1.96582	-0.71910E-05	+0.67006E-04	-1.96272	+0.35681E-04	-0.20453E-04
+3.93006	+0.76891E-05	+0.52548E-04	-3.92700	-0.13447E-04	-0.50021E-04
+5.89428	-0.13538E-04	+0.19816E-05	-5.89125	-0.44655E-04	-0.61670E-04
+7.85871	+0.50403E-04	+0.36582E-04	-7.85564	-0.18547E-04	-0.16002E-04
+9.82286	-0.24717E-04	-0.67876E-04	-9.81984	-0.36486E-04	-0.58591E-04
$- RC = 30.0 \text{ msec}$					
+0.66170	+0.46014E-05	-0.33164E-05	-0.66071	-0.23688E-04	-0.70630E-04
+1.32288	-0.85033E-05	-0.80818E-05	-1.32185	-0.70112E-05	-0.25865E-04
+1.98408	+0.51033E-05	+0.13864E-04	-1.98291	+0.84297E-04	-0.93532E-04
+2.64531	+0.38868E-06	+0.17489E-04	-2.64424	-0.54130E-04	-0.16805E-04
$- RC = 100.0 \text{ msec}$					
-0.10090	-0.34403E-04	-0.46130E-04	-0.09785	-0.21149E-05	+0.57297E-05
+0.20026	-0.43383E-04	-0.54890E-04	-0.19726	-0.30531E-05	-0.47017E-05
+0.29967	-0.20458E-04	-0.31746E-04	-0.29663	+0.23945E-04	-0.31610E-04
+0.39905	-0.35576E-04	-0.46644E-04	-0.39603	+0.22954E-04	-0.30529E-04
+0.49843	-0.24556E-04	-0.35404E-04	-0.49543	-0.98998E-05	+0.17385E-04
+0.59780	-0.39620E-04	-0.50249E-04	-0.59481	+0.16845E-04	+0.24241E-04
+0.79659	-0.15729E-04	-0.25919E-04	-0.79363	-0.19211E-04	-0.11995E-04
+0.99536	+0.22374E-05	-0.75135E-05	-0.99236	+0.12617E-04	+0.19653E-04
+1.19413	-0.222214E-04	+0.12902E-04	-1.19113	+0.16508E-04	+0.23364E-04
+1.59167	+0.38040E-04	+0.29606E-04	-1.58868	-0.78267E-05	-0.13295E-05
+1.98914	-0.28099E-04	-0.20543E-04	-1.98615	+0.15670E-04	-0.21808E-04
+2.98299	+0.31473E-04	-0.26113E-04	-2.98003	-0.25034E-04	-0.19794E-04
+3.97689	+0.66753E-04	-0.63588E-04	-3.97383	-0.18225E-05	-0.25192E-05
+4.97070	+0.52244E-04	-0.51275E-04	-4.96775	-0.58399E-04	-0.54956E-04
+5.96446	+0.42020E-04	+0.43247E-04	-5.96154	-0.39262E-04	-0.36716E-04
+6.95838	-0.51056E-04	-0.54479E-04	-6.95539	-0.19807E-04	-0.18160E-04
+7.95234	-0.59881E-04	-0.65499E-04	-7.94935	-0.50034E-04	-0.49286E-04
+8.94608	-0.30660E-04	-0.22846E-04	-8.94321	-0.36786E-06	-0.51737E-06
+9.93973	-0.15088E-03	-0.14087E-03	-9.93691	+0.10877E-03	-0.10772E-03
$- RC = 300.0 \text{ msec}$					
+1.98786	-0.26330E-04	-0.77531E-04	-1.98683	-0.84337E-04	-0.14093E-03
+3.97528	-0.35531E-04	-0.60585E-04	-3.97429	+0.27994E-04	-0.11118E-03
+5.96257	-0.75553E-05	-0.46194E-04	-5.96167	-0.20693E-03	-0.14804E-03
+7.94987	-0.17114E-04	-0.14967E-03	-7.81632	-0.15081E-03	-0.34226E-03

D Deviation from Straight Line: Graphs

These are the graphs showing the deviations from a perfect fit to the measured voltages. The data is taken from Appendix C. The X axis is V_{out} in volts, and the Y axis is ΔV_{out} . The multiplier for ΔV_{out} is found directly above the Y axis. There are sixteen graphs (eight per page) for each of the four INTEGRATORS, or two per Time Constant.

The left column has the error from the Local fits, corresponding to $V_{in} > 0$ and $V_{in} < 0$. Since V_{out} is proportional to the negative of V_{in} , $V_{in} > 0$ is actually shown on the negative side of the ΔV_{out} axis. The right half of the page shows them for the Global fit, which is over all $V_{out} \neq 0$.

Figure 4: Integrator Number 1 Deviation Graphs



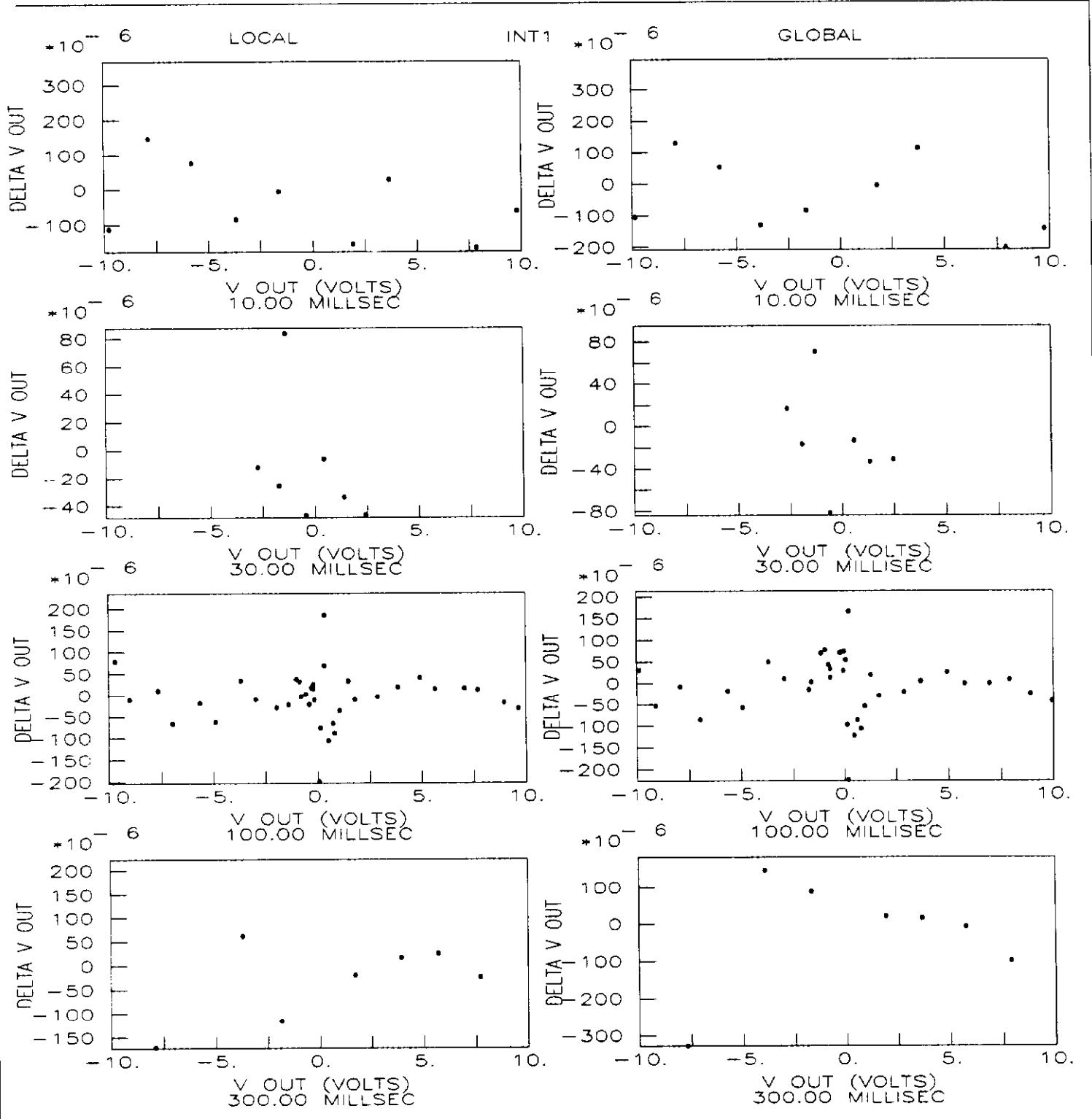
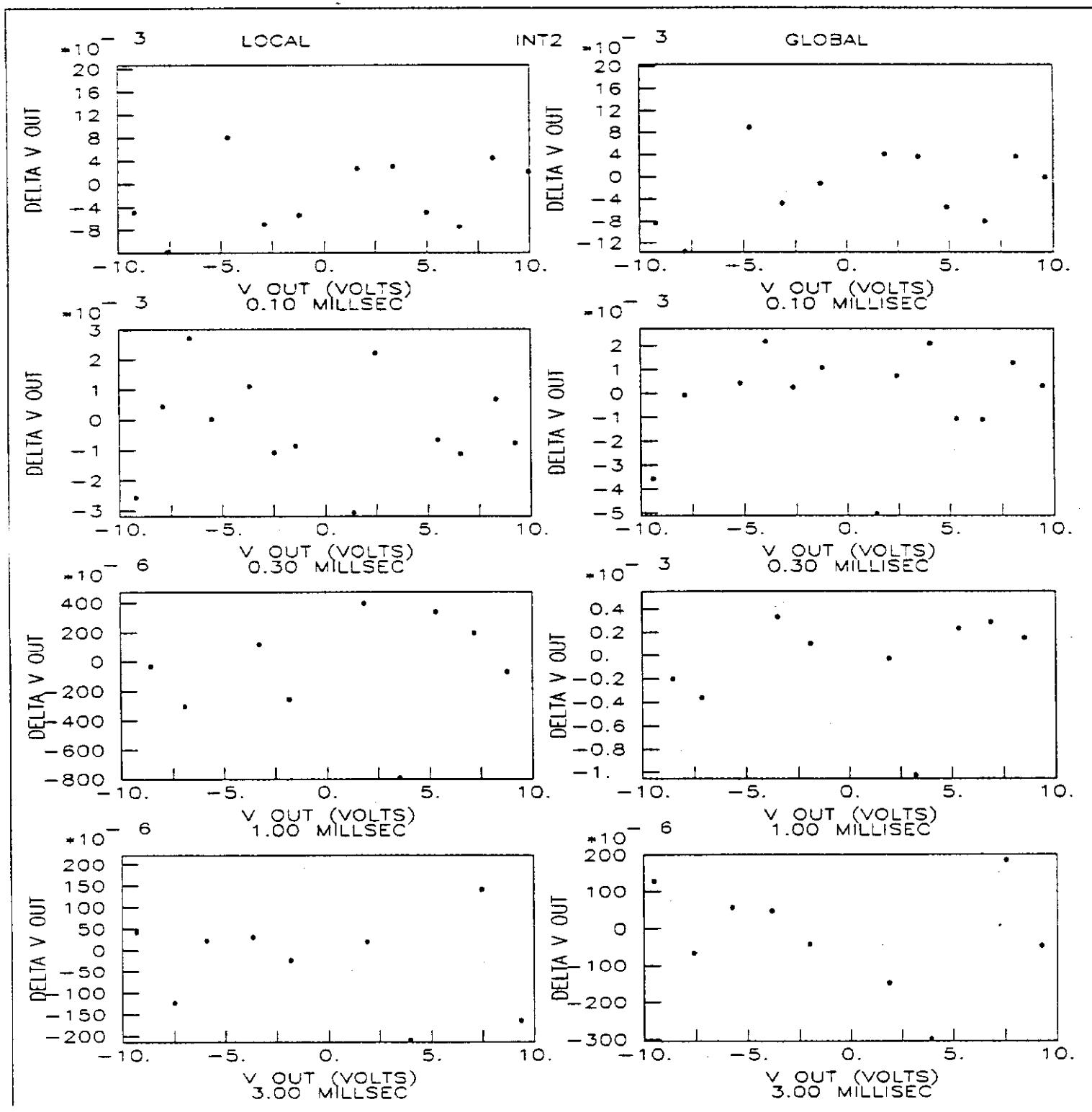


Figure 5: Integrator Number 2 Deviation Graphs



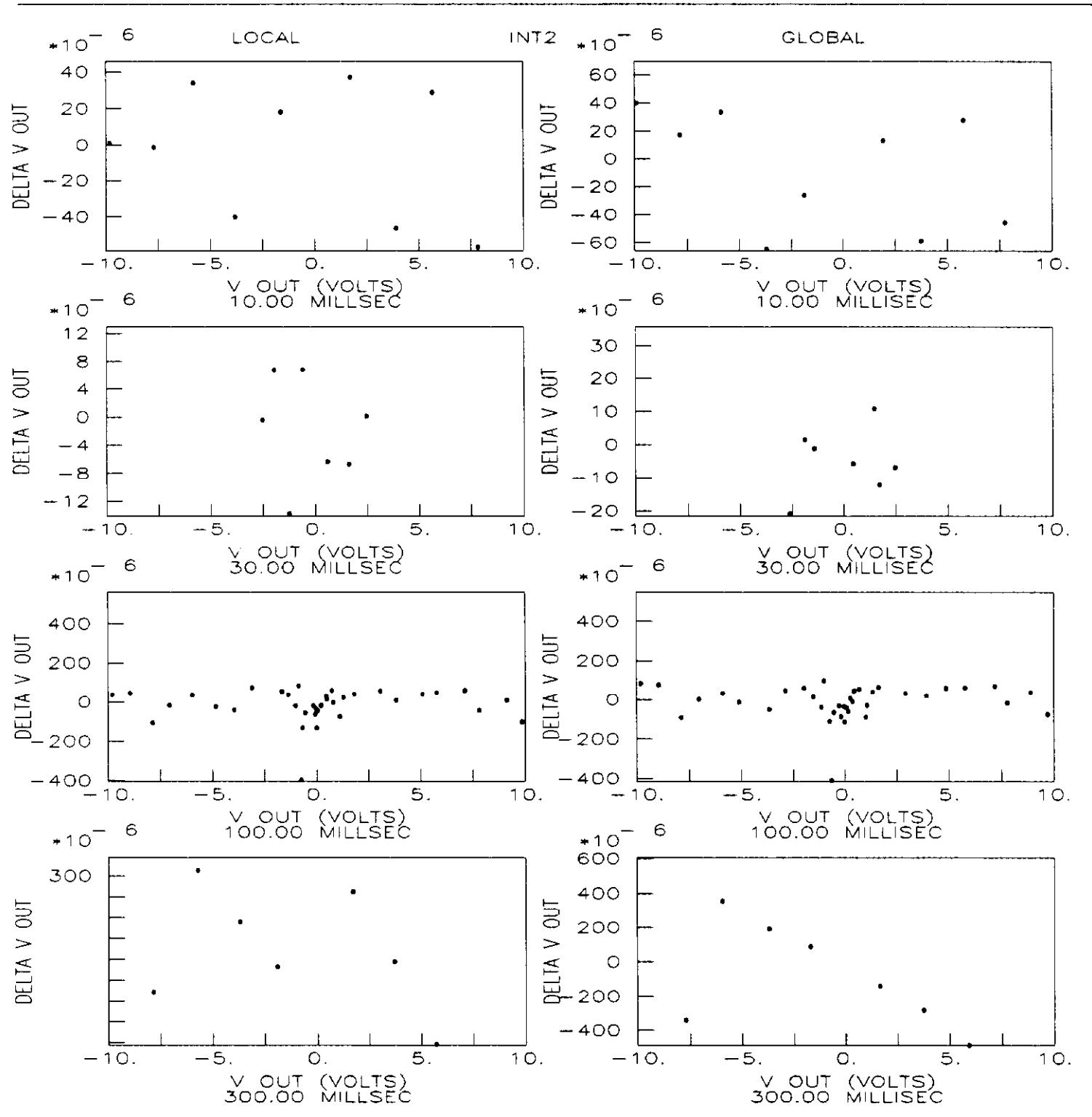
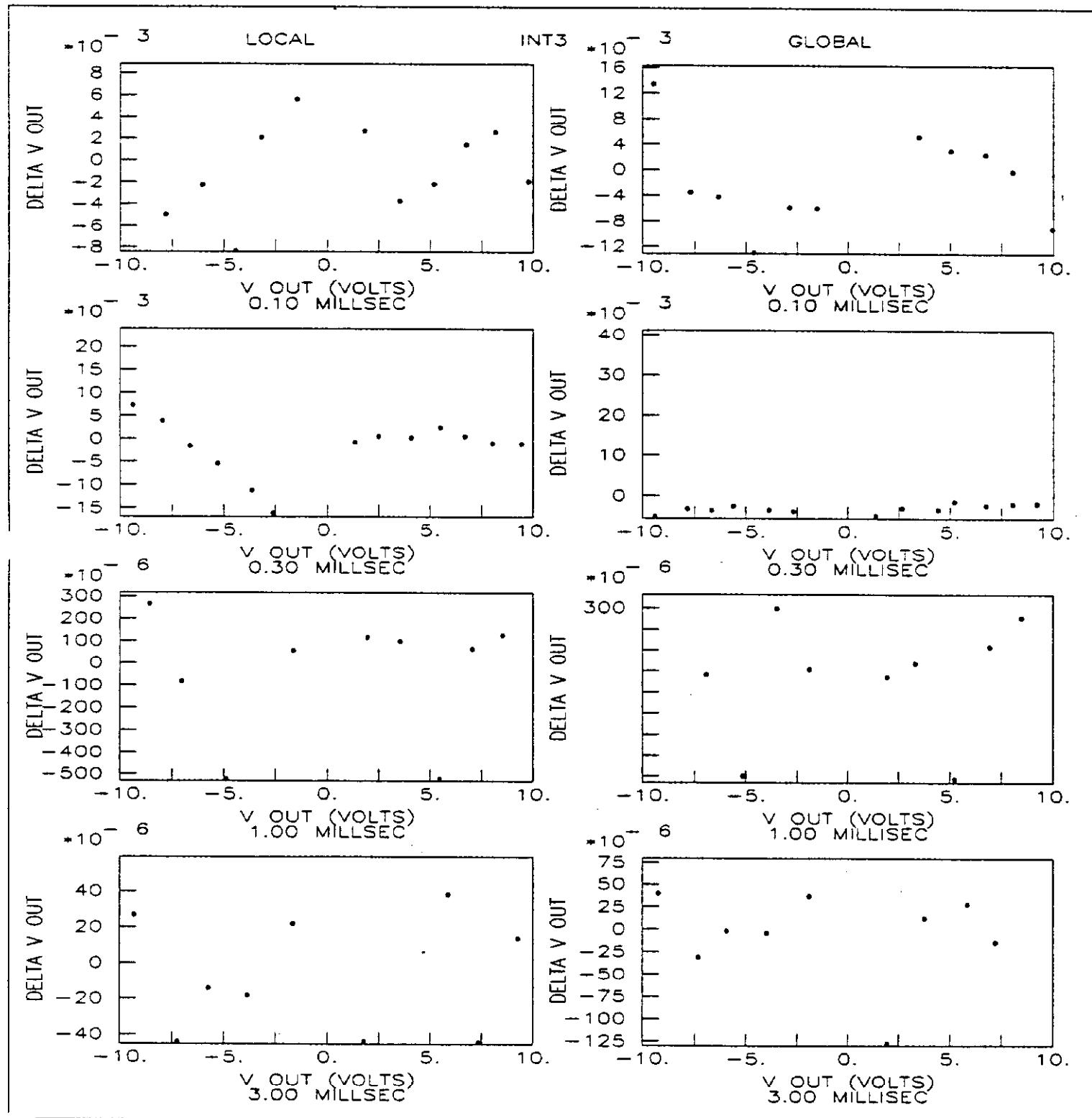


Figure 6: Integrator Number 3 Deviation Graphs



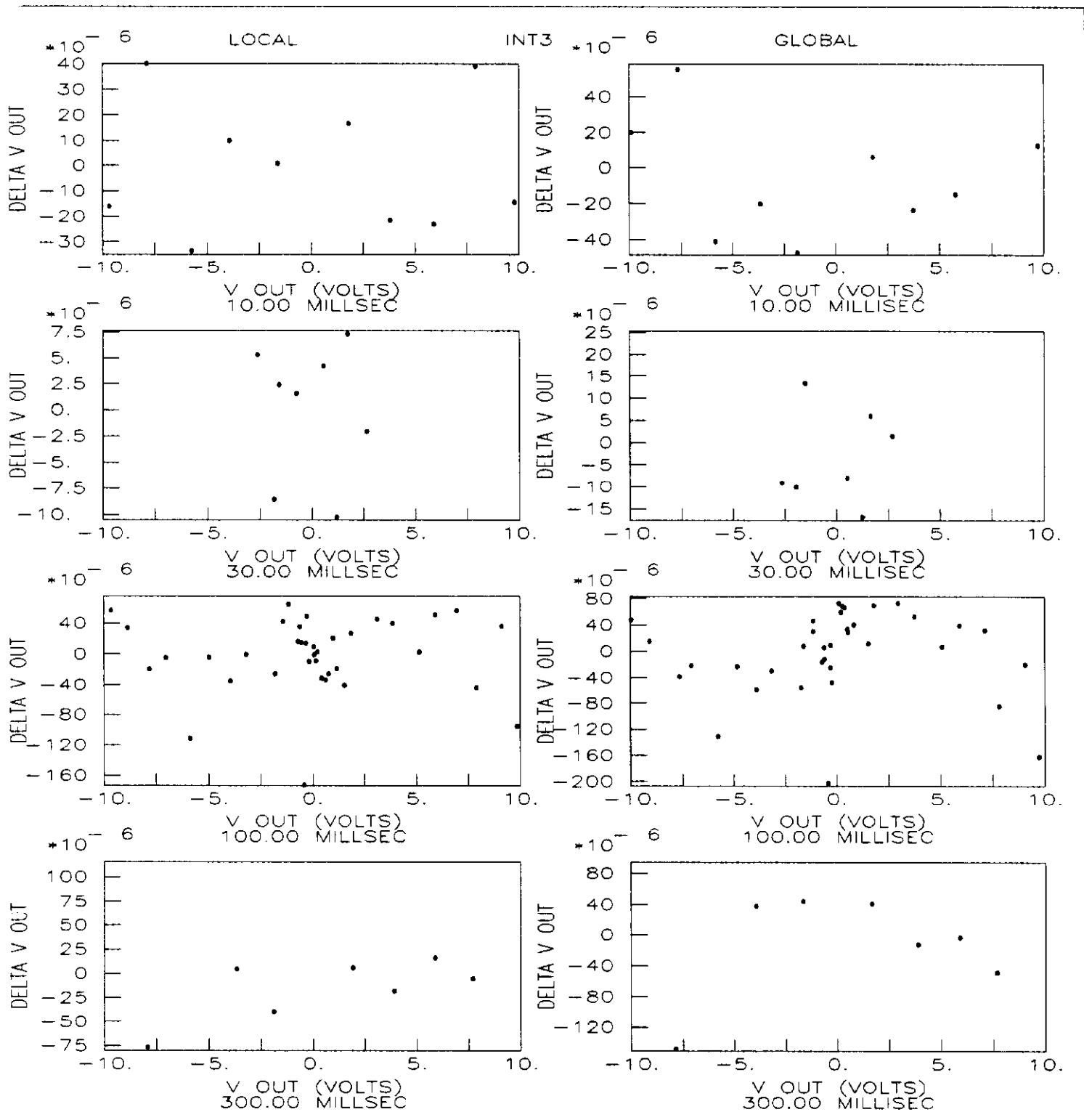


Figure 7: Integrator Number 4 Deviation Graphs

